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SCIENCE AND FAITH

The Spiritual Law in the Physical World

By
W. K. AZBILL, A.M.

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We are aiming, not at those things which are seen, but at things unseen; for the things seen are temporary, but the things unseen are eternal.
—Paul.

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INTRODUCTION

The great problems of science that still wait for solution pertain to very familiar things, and they are properly classed as elementary and fundamental. Scientists and philosophers admit frankly that they do not yet know what anything is essentially. Whether or not all the so-called material elements are resolvable into one primitive elemental substance is under discussion. In what manner, or by what agent, the distribution of the atoms of the atmosphere is maintained, is explained by a theory that lacks confirmation and that contradicts several persistent old theories. The prime causes of magnetism and of gravitation are barely apprehended. There are many physical relations in the Solar System which astronomers naively declare to be independent of gravitation and which they are unable to explain. Whether life is a real essence or a mere chemical reaction is a problem that has recently awakened profound interest.

Even this partial enumeration of elementary things that are still beyond the ken of the greatest savants, suffices to account for the modesty of the foremost scholars of the age; but even

more strikingly does it indicate the enormity of the presumption of that class of specialists who have of late become so pronounced in their declarations concerning what does not exist in the universe, and as to what can not be the prime causes of those phenomena which still wait for explanation.

If one could ask a mite to express a serious judgment concerning the universe, it would doubtless answer, "Cheese." A mite is a specialist in cheese. If the inquiry were pressed with a view of obtaining from this specialist some notion of a vital agency in the production of cheese, it would probably answer, *"Nothing but cheese!"* Could the mite be supplied with adequate verbiage for expressing its views in the manner of a scientific specialist, it might add, "In the present state of our knowledge, in which is summed up the observations of the *mitey* experts in cheese, we find no justification for saying more, or other, than simply *cheese!"* Considering its sphere of operations, no fair-minded person would blame the little philosopher for its limited conception.

The writer believes that the progress in knowledge, made during the past three-quarters of a century especially, enables at this time a nearer approach to an understanding of some of our human problems; and he has attempted in

the several chapters of this volume to systematically blaze a way leading toward the penetralium of their mysteries. There is no class of thoughtful persons for whom the topics discussed have not a vital interest. But there are very many capable people who, for lack of opportunity, or of inclination, have failed to acquaint themselves with those main facts and principles which are indispensable to the elucidation of problems of this kind. To enable this class of readers to give intelligent attention to current announcements and discussions relating hereto, the utmost care has been taken in the course of the following study to supply the needed data for an intelligent apprehension of the themes treated. As much as has been possible, unfamiliar technical terms and formula have been avoided, to adapt the work to the requirements of the general reading public. It is believed that any one of ordinary intelligence will be able to follow the line of thought.

The facts, that every known phenomenon is capable of being expressed in mathematical terms, that the reciprocal actions of the agents involved may be represented by mathematical equations, and that Nature's processes are so uniform and so invariable, where conditions are the same, that results may be predicted with mathematical accuracy when the exact physical

conditions and relations of all the elements of a phenomenon are known, should be of great interest to every thoughtful person. For the shorthand writing of physical specialists it is convenient to employ such mathematical terms; but it is not necessary to do so in order to express clearly and accurately scientific conceptions. Indeed, it is not always desirable to use those highly technical expressions, even when writing or speaking for technically trained readers and hearers. In a work intended for all classes of readers it is deemed to be wholly undesirable.

The writer has no desire to appear learned in the technique of the sciences, the facts of which are appealed to in this study. He entertains no fear of sneers on the part of capable persons having expert knowledge. These, to whose class he is most indebted, will most readily apprehend the main design of the work, and will most thoroughly understand his motive for adopting and strictly adhering to the simplest possible diction throughout the work. The only fear in regard to the treatment of the subject is, that some quite capable readers may fail to pursue the themes upon the unjustifiable ground that they are incapable of doing so intelligently.

If any physicist, or astronomer, of first-class acumen and training should chance to take up the volume, it might interest him to be told in

advance that a good many conceptions which are current in scientific text-books are called in question as being untenable; but he would be pleased to note, and especially he would be able keenly to appreciate, the facts and arguments cited from his brethren to justify the objections in every instance. Certain assumptions of the Kinetic Theory of Gases, and of the Doctrine of the Conservation of Energy, the notions of Surface Tension and Latent Heat, the conception of a frictionless region for atomic and molecular activities, and Sir Isaac Newton's conclusion that no force from behind is needed to drive the planets along their orbital courses, may be mentioned to intimate to such a reader the kind of hypothesis herein restudied. But in showing such conceptions to involve errors, just discriminations have been attempted, and due recognition has been awarded to those investigators whose findings have rendered saner conclusions attainable. There is neither lack of respect for so-called "scientific authority," nor cringing in its presence.

The work is elementary in the sense that it deals with elementary substances and essences, and makes no attempt to treat them exhaustively. A single line of thought is pursued throughout; and, therefore, the components of Nature are viewed in a few special aspects. A

view is had to the larger significance of the ascertained facts of the sciences. Naturalists, biologists, physicists and astronomers are setting themselves and one another upon a saner tack for avoiding entanglements heretofore encountered in the Saragossa Sea they are trying to navigate, where the weeds afloat are hypotheses; and one aim of the work is, to tauten a little of the rigging for the setting of this tack. Another aim is, to contribute something toward the emancipation of that large class of persons who are in an intellectual chain-gang, where the fetter of their thralldom is scientific authority. If it is a boon to have religious liberty in our thinking, it is none the less a blessing of freedom to have our own ideas and opinions about the phenomena of the universe. To merely float on the Gulf Stream of current philosophy, is to drift inevitably towards the frigid region of agnosticism and anarchy; and it is needful for the thoughtful people of this age to make a new declaration of independence; that is, of intellectual independence, to avoid a trend which the facts of science do not warrant. An appeal to reason is made against this trend.

The philosopher, Henri Bergson, of the College of France, has compared modern scientific observations to moving pictures, which are obtained by cinematographic machines. To

elaborate this notion somewhat beyond his intention, the motion films exhibit series of acts which appear to be continuously successive; but, in fact, there are intervals of time between the acts shown, and it is quite possible, by means of a duplex machine devised to make exposures alternately, to show on separate films those acts which occur in the intervals. Supposing two films to have been thus exposed, each would exhibit a true history of the movements of the objects photographed; but neither would exhibit a complete history thereof. Each would tell but half the truth. This illustrates why it is not necessary to deny the facts of science in making the statement that the showing of modern scientists is inadequate. At best our current philosophy consists of half-truths, accounts of partially understood phenomena, and scientifically exact misrepresentations of the processes of Nature.

Take, for instance, the laboratory representations of what sound waves do. Every component of these waves, as misrepresented in so-called photographs thereof, depends for its configuration upon the mechanism of the device by means of which the record is made. In one method of producing sonoriscripts a very thin diaphragm is suspended so as to be free to oscillate quite readily after the manner of a mari-

ner's compass, but with more delicate adjustment. Fixed by axial pins, say north and south, which impinge upon an enclosing ring, this ring similarly fixed at the points east and west, oscillations in all directions are made possible; but, conditioned by the fixed bearings, the chief oscillations will be to north and south, and to east and west. Therefore, when a pencil of light is directed to a photographic film, or to a screen, by the oscillations of the diaphragm, its tracery will be shown in lines mainly in horizontal and vertical directions. The vertical lines will lie further apart in proportion to the speed with which the film is made to move behind the shutter of the camera. Besides, at the end of each lilt, in the halt before the succeeding lilt, the exposure will be of longer duration than at other points along the lines of the tracery, producing an effect due rather to the inertia of the diaphragm than to the impact of sonorous waves. But the sonorous pulses are propagated in all directions from the source of the sound, and their effect in the sensorium of the listener, in the absence of resistance or causes of reaction, will be the same at any point in any direction within audible range. Therefore, the total result of the experiment must be but a partial record of the sonorous pulses, plus the record of the limitations of the machine.

In every field of science allowance must always be made for the imperfections of instrumental equipment and for other sources of error; and, therefore, very many of the determinations arrived at with the utmost care on the part of the most renowned experimenters in chemistry, physics, and astronomy, are but close approximations, as is well known by all specialists. This is not meant to minimize the value of laboratory equipment. It is indispensable and invaluable. But the intimation is that the end is not yet, and that the psychological moment has not arrived for the final trumpet-blast which is to herald the last scientific judgment. Even if the facts were all in and verified, the final conclusions to be reached from them would be still a long way off, as is indicated by the wide differences of the hypotheses entertained, and by the tentative way in which they are held.

At a meeting of the American Association for the Advancement of Science, held recently in Cleveland, in closing his vice-presidential address, Mr. Robt. A. Millikan, after reviewing the latest conceptions of physicists "On Unitary Theories in Physics," said, and was loudly applauded for saying: "In conclusion, then, there is at present no quantum theory which has as yet been shown to be at all consistent with all the experimental facts now before us; and yet,

it looks as though some kind of atomistic theory of radiation had to come. Certainly, never in the history of the world has physics offered greater tasks to her followers than she now offers; and never were more and better brains needed for the accomplishment of these tasks. It may be that thou art come to the kingdom for such a time as this."

There is a note of appeal, if not of warning, in that beautiful verse of Esther from which his quotation is taken, to-wit, "If thou altogether holdest thy peace at this time." Who knows but that these words may have nerved him for his sweeping assailment of current hypotheses in his special department of science? Anyway, at whatever risks there may be, surely every one who has a suggestion of possible value to offer, should venture into the Court of General Intelligence and should make his plea for an audience, though he may never be permitted to touch the top of the golden scepter.

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I.

The Ether of Space.

"The Ether of Space" is a cumbersome name for the all-pervading, subtile essence now believed by physicists to be the medium of interplanetary effects. The qualifying words are employed to distinguish it from sulphuric ether, but ordinarily "the ether" suffices. The word in both uses is derived from the Greek word *aither,* which was the name of the atmosphere of the gods; and, by the adoption of it to designate an extremely attenuated and refined element, the scientists have paid a pretty compliment to the Greeks, if not also to their deities.

Like its associate essence, electricity, it has but recently become known to mankind; and in connection with each the sayings are being verified, "The last shall be first," and "The greatest of all shall be the servant of all." Since they have become our ministering domestics and their names are household words everywhere, it is desirable that their nature and the manner of the performance of their functions should be better understood by all those whom they serve.

So subtile is the ether, we can never have the mediate knowledge of it through the sense organs which we have of the common objects about us. Even conceding that things apprehended by the senses are immediately known, it will still be true that we can never know by immediate perception that the ether exists. Yet, we may be so certain of its existence as to consider it a real and indispensable means of our own existence. For through its agency both light and heat are transmitted to our planet from the sun. Like life, for instance, the life of a lily, or of a canary, it makes itself known to us through its effects; and these effects must take place in other elements arranged into a system apart from our own organism, of which electricity must be a component, itself an essence we can not perceive immediately.

The manifestation of life in the plant and in the bird, observed in normal action and then suddenly seen to cease entirely, though all other essential parts of the organism remain intact, suggest to the thoughtful mind the presence of a something potential, though intangible, to account for the manifestations. Probably the first, and certainly one of the easiest, discoveries of the kind was that of the wind, which can not be seen, though it is breathed, and can be felt. It is no wonder that the primi-

tive notion of life was that it consists of the breath. In both Greek and Latin the words for the wind are the words for spirit; for "the breath of life" is a very ancient notion. It survives in our phrase "to expire," meaning the giving up of life with the breath. But, in spite of lingering false notions, people of all races early became convinced that life is different from the wind. The Greeks made the distinction (*pneuma zootikon* and *pneuma psykikon*) between lower and higher kinds of life in the animal kingdom. Their discovery was of the order of our modern discovery of the ether.

First, men of science noticed that solids can be permeated by liquids without any displacement of parts or impairment of structure. Then it was found that liquids are permeated by gas without increasing their volume. The hypothetical conclusion was reached that the particles of solids and liquids are not in immediate contact, and that not even the atoms composing molecules are ever in immediate contact. Naturally, the question was finally mooted, By what is the interstitial space within matter occupied?

One of the greatest thinkers of the seventeenth century, Robert Hooke, in discussing the essence of matter, compared what he considered the densest and heaviest with the rarest and

lightest of all substances; namely, *gold* with the *æther*. He described the latter as "the substance that fills the cavity of an exhausted vessel, or cavity of the glass of a barometer above the quicksilver." Then he proposed to prove that "this cavity is more full, or a more dense body of æther, in the common sense or acceptation of the word, than gold is of gold, bulk for bulk." He argued that "vacuity, as it is commonly thought, or erroneously supposed, is a more dense body than gold as gold."

Sir Isaac Newton, a contemporary of Hooke, who philosophized and wrote later in the century, noticed that heat affects a thermometer in a vacuum almost as readily as when not in a vacuum; and he at once raised the question, "Is not the heat of the warm room conveyed through the vacuum by the vibrations of a much subtler medium than air, which, after the air is drawn out, remains in the vacuum?" Then the further questions, "Is not this medium the same with that medium by which light is transmitted, and by whose vibrations light communicates heat to bodies? And doth it not pervade all bodies? And is it not, by its elastic force, expanded through all the heavens?"

Another of Newton's surmises appears to have been made with Hooke's hypothesis in mind, for he asks, "May not planets and com-

ets, and all gross bodies, perform their motions more freely and with less resistance in this æthereal medium than in any fluid, which fills all space adequately without any pores, and by consequence is much denser than quicksilver and gold?"

It is a fact worthy of remark that the only way in which the influence of the ether on the motion of the planets occurred to the mind of Newton was as to whether they move freely through it. It is a matter for surprise that no scientist or physicist or astronomer from Newton's time to the present has attributed to the ether any directive influence over the motions of the planets. Though a few men of local reputation have suggested that it may possibly retard their motion, or at least that a planet may experience some resistance by the ether, no one within the present writer's knowledge has ever mooted the question whether it may or may not facilitate their motion.

With Newton the transmission of light from the suns to the planets of the whole universe was its all-important function; and, being essentially involved in his corpuscular theory of light, he called it "the luminiferous ether." But the present state of knowledge enables us to take a wider view of its functions in the scheme of Nature. Even Newton might have called it

"the caloriferous ether"; for he was aware that it transmits heat as well as light. But "the sonoriferous ether," or "the magnetiferous ether," or "the ponderiferous ether," would be equally adequate descriptions—or inadequate descriptions—of it. Its actions relate to all these things, and to other things equally far-reaching in physical effects.

So numerous are the requirements for an inter-planetary medium, and so convincing have the proofs of its existence become, that what was at first suggested hypothetically is now boldly put forth as thesis; and almost all physicists and astronomers accept the idea of "the ether of space," or of the essence this phrase stands for under some other description. Still, the questions, "What is it?" and "What are its several functions?" continue to wait for complete answers. In this connection it should be remembered that we do not know what hydrogen is, for instance. We merely know how it behaves in relations with other elements, and what results follow its action upon them or its combination with them. Our knowledge of the ether lies within this scope.

In any successful effort to understand the intangible, thingy things must be distinguished from non-entitative things. The conditions require the inter-planetary medium to be entita-

tive, substantial, real. It exists, not merely as a condition of some substance, but as an actual entity. To illustrate, a wave on the surface of a liquid is a condition of the liquid, but is not in the same class of things as the liquid is.

Of course substantial things will produce effects when in a given condition which they will not produce when in some other conditions, and, therefore, there are effects of effects. A wave can be seen, and heard, and felt. The wave-effect in the liquid produces wave-effects in the ether; and, by these, effects are produced in the sensorium of living beings. From this it may be perceived that effects may occur in a series. A wave traversing a lake falls on the beach; the impact causes tremors in both the land and air adjacent; these tremors, through the media of electricity and the ether, affect our organs of perception; and through our organs the effect is produced which we call conscious perception. In this series both entitative and non-entitative causes operate to produce the effects. The water, the earth, the air, electricity, the ether, and the nerves of the sentient being, are all entitative agents; but the waves, the agitation of the electric charges of the matter involved, and the pulses in the ether, are non-entitative causes. Still, they are none the less indispensable.

Here, again, a step-by-step progress from one medium to another is noted. There is a transmission of effects from liquid to solid matter, from solids to gases, and from all these to the more subtile essence mentioned, and in the end of the series, from substantial essences to the mind, or soul, or life of the sentient being. There is such an infinite variety of effects in the sundry elements of Nature, which are so delicate, so interwoven, so complicate, so nearly instantaneous, and so rapid in succession, that to transmit them even from one material substance to another requires the agency of excessively refined and attenuated essences. But more especially is such an agency required to preserve throughout a long series of transmissions all the delicate, interwoven and complicate effects, and to faithfully deliver the impressions of them to an immaterial recipient across the chasm between matter and life. The ether is adapted for this agency.

It is easy to understand how electricity facilitates the transmission in the series above mentioned. Every atom of the earth, of the water, of the air, and of the nerves within the organs of the sentient being, is enveloped in an electric integument; and these electric corpuscles constitute a continuous medium throughout the entire series. It is obvious, also, that

electricity is responsive to every variety of the effects transmitted. The inference is reasonable that it alone may be capable of the delicate service performed. But if one contends that it is capable of all known inter-planetary effects, he must prove that it is evenly distributed throughout inter-stellar space. Here arises, then, the necessity for such discrimination as has been made, or as may with reason be made, between electricity and the ether. Is it comparable to the difference between water and steam, or to that between oxygen and hydrogen? Are there two subtile essences concerned with the phenomena of transmission of light, heat, sound, and motion, or is there but one? If but one, it is *immaterial* (?) whether we call it electricity or the ether.

The reluctance of electricity to leap even a small gap in a conductor, or to traverse a vacuum, and all the phenomena that show its inclination to cling to matter, appear to forbid the conclusion that it is evenly distributed throughout space. But, rightly understood, these facts are not conclusive evidence against the conception. This will appear in succeeding pages where the nature of the essence is more fully considered. Yet, if a distinction is to be made, it must proceed upon the same lines as those according to which we discriminate

between oxygen and hydrogen, between silver and gold.

During recent years a set of ideas has been gaining attention and general acceptance, respecting the constitution of all substances, according to which the eighty several elements of the material world are derived from one fundamental element.

With Lord Kelvin, Clerk-Maxwell, and some others, motion is the fundamental thing. With Sir Oliver Lodge, and many others less generally known, it is the ether of space. Physicists of the class of Sir William Ramsay and the German philosopher, Th. Wulf, are searching for it in the "radio-active substances," the latter inclining to the opinion that helium is the fundamental substance. The several classes of thinkers neither differ entirely nor entirely agree on the several problems involved. It is merely meant here to intimate what certain of them have emphasized. Clausius, Haeckel, and Ebert, all German, find their genesis in *energy,* but with conceptions too divergent to justify making one class of them.

Maxwell suggested the hypothesis of permanent rotary motion of molecules in a frictionless region; Kelvin devised models of gyrostats to show how "permanent motion" would impart to them properties identical with those

of elastic solids. Helmholtz, in 1893, according to Ebert, prepared a paper on "Permanent Motion as Apparent Substance"; and Lodge has written several treatises in explanation of the hypothesis that all forms of matter may consist of "whirls" or "knots" or "vortices" or "twists" in the ether.

To avoid misrepresentation in any attempt to abbreviate illustrations used by the scholars, and at the same time to fairly set forth the conception that all the elements may be but forms of a fundamental substance, let water be conceived of as the primitive essence. Then ice, frost, snow, hail, dew, rain, vapor—cold and hot—are the several all-water elements derivable from it. Observe that neither ice, frost, nor snow is as dense as the primitive element. Ice floats in water, because it is less dense. Yet, it opposes resistance more sensibly. Now, if the water be taken as the ether, and ice as iron, the latter is all ether, yet less dense when considered separately. But afloat in the ether, it is pervaded by the ether; so that, within the whole of the space occupied by the iron, there is not a conceivable point of its substance or within its limits that is not occupied by the ether.

In an article on "The Constitution of Bodies," prepared for the Encyclopedia Britan-

nica by Clerk-Maxwell, gases are described as "fluids any portion of which, however small, is capable of expanding indefinitely so as to fill any vessel, however large." But the atmosphere of the planet consists of gases; and space is the one container of them all. If they are capable of indefinite—that is to say, infinite—expansion, and of filling any container, however large, then the whole region of space must be filled with infinitely attenuated gases. Supposing this to be true, the question is still an open one as to whether the conceived process of their formation from the ether is reversed in interplanetary regions, restoring them to the primitive etheric form.

Dr. Ebert, Professor of Physics in the University of Keil, says in his work on "Magnetic Fields of Force," page 45: "We can avoid, then, introducing into our conception another hypothetical substance—the so-called ether. It can be shown that all regions which we are able to investigate are filled with matter. For example, a Torricellian vacuum, above the mercury in a good barometer which has been well boiled out, still contains so much vapor of mercury and of glass, that even here we do not need to invoke the aid of any special medium for the transmission of the stresses which constitute the magnetic field."

Had he left this statement unmodified, the just inference would be that he supposes all inter-planetary space to be occupied by vapors from the planets; for he distinctly teaches that inter-planetary space is a vast magnetic field. But he adds parenthetically a most pregnant paragraph:

"But as the transmission of magnetic effects does not become perceptibly less as the number of the molecules per unit volume is reduced, *we must suppose that the principal transmission agent is something other than the molecules.*"

There is just one way to reduce the number of molecules per unit volume in a vapor, and that is by expansion. Here, then, he implies that there may be an expansion to an extent which reduces molecules to "something other than molecules." Fortunately, he has not left us without a clue to what he supposes that "something" to be. On pages 40 and 41 of the same volume, he elucidates as follows:

"The field due to a magnetic pole is in some degree impenetrable by the like pole of another magnet. When we stretch out our hand and suddenly feel a resistance to its movements, we say that there is 'something there.' To this something, which resists penetration of other bodies into the space it occupies, we give the name of 'matter.' The effect observed is also

summed up by saying that the region in question is filled with a certain form of energy, which resists a diminution of volume. The knowledge that a magnetic field is a region filled with energy of a special kind is of very great importance."

From all this it is apparent that, according to Dr. Ebert, planetary vapors are dispersed and attenuated in the magnetic field between world and world till molecular structures disappear, and till the matter takes the form of *energy*. Of course, it is "energy of a special kind." It opposes resistance to other matter in the same form; it opposes resistance to matter of all kinds (Faraday), being a magnetic field; and it performs all the functions of an inter-stellar medium. In fact, it is essentially "the ether" of the English physicists transmuted into German "energy." But energy, from *en* and *ergo,* means merely *in the work;* and it properly connotes a condition rather than a substantial entity. Therefore, the conception of the English physicists is to be preferred to that of Dr. Ebert.

Touching one item only in all this discussion are all the physicists and astronomers in accord. All concede and hold that there is an entitative medium between the suns and their attendant planets by means of which light and heat effects are transmitted. But not one of

them holds, or ever has held, that there is a particle of convincing proof that any of the eighty known elements has been derived from the essence of that medium, whether it be called electricity, the ether, or energy. A number of hypotheses have been suggested. A good many facts have been revealed in the course of investigations which, if the hypothesis of a fundamental essential source of the several elements should turn out to be true, would harmonize with it. Besides this, all that can be considered favorable to this hypothesis is the manifest desire of the philosophers to believe in it, and thus establish another outpost on the line of advance towards the limits of knowledge. There appears to be nothing within the scope of reason or of any form of revelation to contravene. All that is lacking is evidence; but it is wholly wanting.

However, supposing this hypothesis to be tenable, the difference between the several elements would be in the peculiarities of the several forms which the ether is capable of assuming. One of these would be the primordial condition; and it would differ from any and all the others as they differ from each other; and it would be classed as a distinct substance on precisely the same grounds as is any other element. On the other hand, supposing this

hypothesis to be groundless, and agreeing with physicists in general and with Ebert in particular, that "there is something there," it must be distinguished from all other essences by the peculiar effects produced by it in its relation with other essences, just as they are distinguished from one another.

Lord Salisbury once said facetiously that "it is the nominative case to the verb 'vibrate';" and that it vibrates, or is agitated into waves, pulses, and commotion of various sorts, is a proposition about which there is almost complete agreement. That it is set in motion, mediately at least, by the suns and by all forms of matter, admits of proof. That it is equally distributed, or evenly dense, throughout interstellar space is made evident by the fact that light-producing waves of all lengths and frequency traverse it in the same intervals of time from our nearest stellar neighbors and from stars as remote from the earth as Algol. If it consisted of components of different densities, as the several elements differ one from another, red light from such distant objects would arrive in advance of blue light at the emergence of Algol from behind its companion. Then, it is of uniform consistence throughout its extent. That it is in a very slight measure inert, is evident from the fact that about eight minutes are

required for light waves to traverse it from the sun to the earth. Its functions include the transmission of light, heat, and magnetic effects. A leading purpose of the present work is, to show that it is the agent to which gravitational effects are due.

That the ether has some relation of homogeneity with the other essences of the universe can not be doubted. It is characterized by entity or substance, and it has the properties of inertia and resistance. In the strictest sense, it can not be said to have dimension; because, so far as our knowledge extends, it is immeasurable—infinite. It belongs at the upper extremity of a long series of the sublimation of design, if not of a natural process, being the most refined and subtile of all the not-living essences. It is doubtless a medium of the operations of Life in the physical world; and, most likely, it is the only essence through which or upon which life acts immediately. On the other hand, it sustains the relations of action and reaction upon all the physical elements; for it pervades them, as experiments with all the alphabet "rays" have shown, and as the resistance to its waves, pulses, and billows by the different elements evinces.

II.

Electricity.

The name of this well-known, and yet unknown, subtile essence, is the survival of a misconception concerning its nature. Over twenty-five hundred years ago some mute, inglorious Greek philosopher observed that when a piece of amber was rubbed briskly with a woolen cloth, it would attract small bits of straw or of woody fiber. About six hundred years before Christ, Thales, of Miletus, described this peculiarity of amber; and some three hundred and twenty-one years before Christ, Theophrastus, another Greek philosopher, described the same thing. The Greek word for amber is *elektron;* and it was supposed that the observed effect resulted from a peculiar property of *elektron.* This misconception passed to the learned Latins, and survived among them; for Pliny, about seventy-five years after Christ, attempted an explanation of the phenomenon in which he betrayed the same ignorance. But Dr. William Gilbert, physician to Queen Elizabeth, and a learned observer, discovered that resin, sulphur, and glass are all capable of the

same effects. Yet he allowed the old, false notion to survive in the name he gave to the element; which was thenceforth to be more thoroughly studied and better understood.

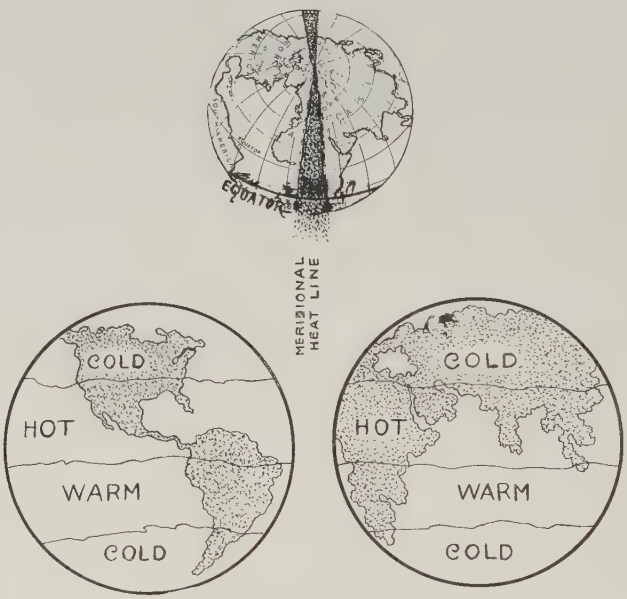
It is known that all sorts of matter can be electrified, by which is meant that a volume of electricity can be accumulated about any piece of matter, and that, while so temporarily surcharged, the electrified matter will manifest this and other effects. More than this, it is known that every piece of matter, from the size of the smallest particle to that of the largest planet, is enveloped by electricity, and that no atom of matter has ever been known to be deprived of its electrical charge entirely.

The several inferences from the fact last stated are very important. One is that no function of matter is ever performed without the presence of this agent. Another is that its never-failing presence with matter hints that its agency is indispensable in any function performed by material elements. No actinic, no physical, no chemical, no magnetic, no gravitational, no astronomical effect, ever occurs without the intervention and assistance of this agent. Another inference is, that all vital processes with which we are acquainted are carried on with its indispensable assistance. For life, like the ether, must always act on matter

through it and, we may safely assert, by means of it.

Kindred to the foregoing, there is a long chapter of facts concerning the volume of electricity which is, or which may be, associated with the various masses of matter. One is that the different material elements differ in their capacity for receiving and for transmitting electrical charges. Pith, vulcanite, resin, and gum will receive and hold for a long time large charges of what is erroneously called "static" electricity; but they are very poor conductors. Every so-called non-conductor exhibits this peculiarity, but in different degrees. On the other hand, silver, copper, aluminum, zinc, platinum, iron, lead, and mercury are conductors whose efficiency is in the order of this enumeration. Metals dissolve under the strain of surcharges, mass for mass, some sooner than others. There is evidence of variable molecular and atomic charges.

The proportion of electrical volume to material mass is so variable as to baffle any attempt at exact classification; but experiment reveals certain crises of electrification which are instructive as to the relation of electricty to such effects as cohesion, repulsion, contraction, expansion, sublimation, evaporation, and gravitation. The present purpose being to give some



Range of the Heat Equator.

general notions of the essence, these critical conditions which are brought about by it may be partially enumerated; but it will be helpful to first draw attention to the prevailing cause of the normal variation of volume, or charge, in connection with matter over the whole surface of the earth.

Since ether waves set in motion by the sun fall on our globe less obliquely at the equator than elsewhere, heat effects from them are most intense along the equatorial belt; and they diminish gradually towards the north and south to the poles. Coincidently, the surface displacement of the planet, due to diurnal rotation, is less swift in the temperate zones than in the torrid, still less swift in the frigid zones, and least so in the polar vicinity. Again, there is a meridional heat-line which lies nearly at right angles to the equator, and which is continually shifting to the westward; and there is, always on the opposite side of the globe, a meridional, cold, midnight line, which lies similarly at right angles to the equator. Currents of electricity that are set in motion by the electro-ethereal agitation whose storm center is at the point where the meridional heat-line crosses the equator, tend (in relation to the surface of the earth) towards the northwest and southwest on the one side of the equator,

and towards the southeast and northeast on the other side, the midnight cold belt and the poles being the region of refuge from the etheric commotion.

In their migration from the torrid zone electrical streams flow chiefly through the atmosphere; but they also move on the surface of the earth. Sometimes their volume is hardly perceptible, and sometimes they pass in flood-tide abundance. Hence the air, and the clouds, and all objects through which and over which they move, are affected by variable charges from day to day and from season to season. Besides these general migrations, there are local movements from one vicinity to another on the earth, and from one cloud to another in the skies.

About the time the Postal Telegraph Company began operations between New York and Chicago, Professor Elisha Gray, a most intelligent observer, undertook some special investigations as to the electrical conditions of the earth and the air along that telegraph line. His findings confirm the statement just made concerning local shiftings of charges on the surface of the earth. He says he found, in almost every instance of change, the currents flowing from points of higher temperature to regions of lower temperature. When the temperature

was lower in Chicago than in New York, the current flowed westward; and when the conditions were reversed, the current flow was eastward. Of course, every thunder-storm furnishes proof of the movement of electrical charges from one cloud to another, and of the passing of the fluid from the clouds to the earth. Its passage from the earth to the clouds and to the upper air is not so commonly known; but this also has been ascertained to be one of its local movements.

Another of Professor Gray's findings enables us to take a somewhat different, yet equally broad, view of the distribution of electricity around our planet. He noticed that ordinarily the atmosphere is positively electrified and that the earth is negatively charged. He states that, in some way, "the sun's rays have power, directly or indirectly, to give the globules of moisture in the air a potential different from the earth." In clear weather he found the air near the earth to be in a neutral condition; but as higher strata were reached, they were found to be more and more positively charged. He reached the conclusion that the upper air and the earth are oppositely charged constantly, like the two sides of a Leyden Jar, or like the two leaves of an electric condenser; and he characterized this condi-

tion of the upper air as "a state of electrical strain."

This confirms the oldest recorded notion touching the suspension of aqueous vapor in a zone far above the surface of the earth. Naively, and especially without any philosophical disquisition in regard to it, Moses wrote in the first chapter of Genesis his statement of this notion. He says that "Jehovah made an expanse, and separated the waters which were under the expanse from the waters that were above the expanse." No language available to any writer of the time in which Genesis was written could have more accurately expressed the truth which Professor Gray independently discovered and set forth. It was said of Moses that he was learned in all the wisdom of the Egyptians. It is a curious fact that this conception is nowhere else found in ancient writings.

The sudden passage of vast charges from the upper air to the earth is an event that results from one of those crises, the partial enumeration of which was deferred in a foregoing paragraph. The bolt from one cloud to another, and the instantaneous leap of the fluid from any surcharged matter to any other mass of matter, follow crises of the same sort. Touching these instances certain differences

may be noted, but they relate to the kinds and conditions of the material masses involved. In the first, the electric surcharge passes between atmospheric gases and solids or liquids of the earth, the latter being enveloped in these gases. In the second, the surcharges pass between vaporous masses which are suspended in the gases. In the third, they pass between solids and solids, or between solids and liquids, that are immersed in and permeated by the gases.

Another critical state of electrification is that at which explosives "let go," as the familiar phrase expresses the instantaneous effect which follows the disturbance of a most remarkable sort of unstable equilibrium. Here, also, the condition of the explosive, being immersed in a gas, or gases, ordinarily, has a determinate relation to the letting go; for in a vessel approximately exhausted of air, neither a spark nor a blaze nor a sudden jar will produce an explosion. Dissolution will take place slowly or briskly in proportion to the amount of air or other gas left in the partially exhausted vessel. The inference is that in a perfect vacuum—a something that is yet to be produced—no dissolution or explosion would occur. But, beyond question as to the fact, every explosion is an electrical effect, and the state of unstable equilibrium exists somehow between

electrified gas and the electrified explosive matter.

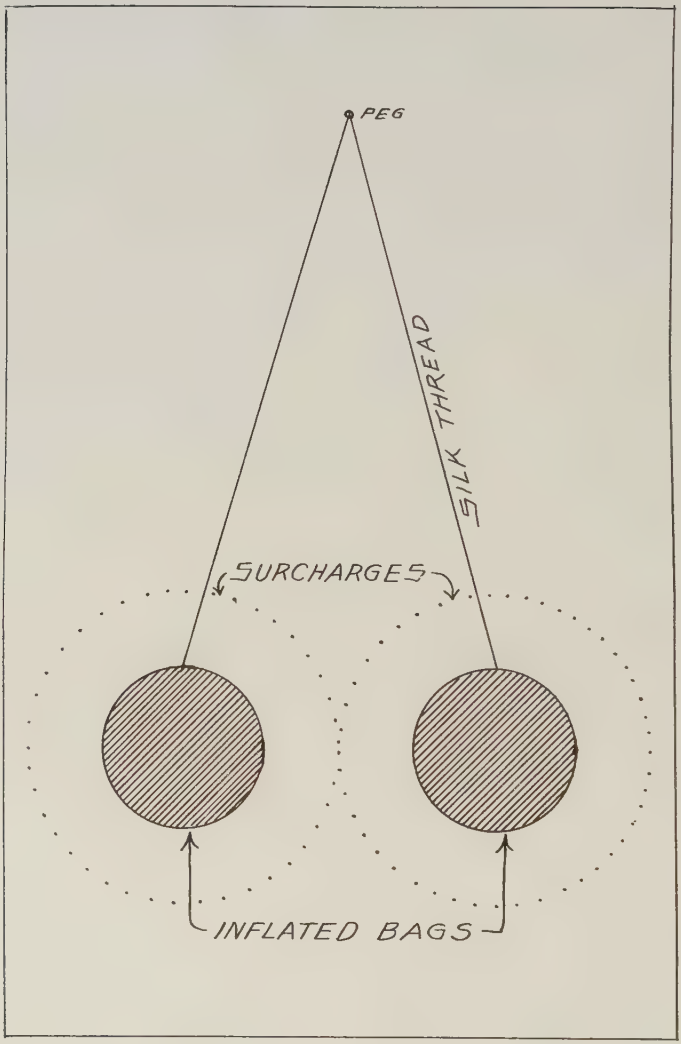
There is a well-known series of crises between the congealed state of water and the state of dissociation of the two gases of which water is composed. These are at the points of sublimation, melting, boiling, vaporizing, and dissociation. The known facts in regard to these are as remarkable as they are helpful in the elucidation of electrical processes. Ice sublimes below the temperature at which it freezes. That is, minute particles of it leave the frozen mass in vaporous form. Ten calories of heat will raise the temperature of a gram of ice from twenty degrees below to zero, centigrade, when it will begin to melt. If stirred, the ice and the water in contact with it will remain at zero temperature, while eighty more calories per gram are being applied to melt all the ice. Then the temperature will gradually rise while one hundred more calories are being applied to bring it to the boiling-point, at the centigrade temperature of one hundred degrees. Here vaporization will begin; but the temperature will not exceed one hundred till the last drop of the water has been changed into vapor. To vaporize the gram of boiling water will require five hundred and thirty-six more calories of heat. Finally, after this critical

point is passed, the temperature of the steam or vapor will continue to rise till it becomes "dry steam"—also called "superheated steam" —which is a mechanical mixture of oxygen and hydrogen, the gases of which water is composed. How much further they may be dissociated by heat is an open question.

Ether waves of the length and frequency to produce heat and light effects beating on matter, perturb its electrical charges and thus operate against cohesion. Under any given atmospheric pressure, there is a degree of perturbation, constant for every solid, at which it will melt. Expansion begins with the heating, the molecules standing further and further apart till the mode of electrification characteristic of liquids is reached. It is reached in different metals at different temperatures; and the zones of temperature at which different elements will remain in the liquid state differ, for the reason that the next critical point above or below melting is higher or lower in one element than in another. This may be verified and the particulars of it ascertained by reference to any good work on physics. The same observations may be made as to reaching and maintaining the vaporous and gaseous conditions of matter. Amazing differences and variations will be found; but all these depend on two things;

namely, the volume of atomic and molecular charge, and the exposure of the element, in any mode of electrification, to ether perturbations of the kind that produce heat and light effects.

The first observed characteristic of electricity is one of the latest to be studied and understood. It is integrative. That is, it appears to attract matter and to form nuclei within its grasp. Just why this happens will be considered hereafter. For the present purpose it is sufficient to mention some evidences of the tendency to its sphericity. Besides the fact observed by the ancient Greeks, that a surcharged mass of matter will attract bits of lint and dust, experiments have shown in a multitude of ways that to increase the volume of the charge is to increase this integrative effect. The surcharged mass becomes a sort of center of gravity to objects which are not similarly surcharged. Then, free liquid particles in the grasp of electric charges become spheres. Dewdrops and raindrops illustrate this. So do leaden missiles which are made by causing the melted metal to fall in particles long distances through the air and into a bath of cold water. Another illustration is seen in mercury particles, which assume almost spherical forms when lying in contact with solid matter, this element being very sensitive to electrical and ethereal influ-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ences. Besides, all so-called "capillary-attraction" phenomena are effects of this integrative tendency of electrical charges.

We have seen that electricity is communicated from one mass of matter to another in two ways; namely, by the slow processes of radiation, diffusion, convection, and all quiet sorts of conduction, and also by instantaneous bolts. These are merely different modes of the disintegration of single electrical bodies; and one of the most interesting of all electrical phenomena is the tendency of such bodies to persist in their integrity.

For an experimental proof of this, let two toy rubber balloons be inflated and suspended by silk cords on one point of support. A sudden twitch or brisk rubbing with the hands will charge them sufficiently, especially if the temperature of the place is low where the experiment is made. When both are charged they will stand aloof from each other, from one foot to eighteen inches. Either of them, if suspended alone, will exhibit polarity, the thicker side of the balloon turning toward the north. But, suspended side by side, even when opposite poles front each other, they will persist in standing aloof. They will maintain this attitude for several hours, and the surcharges will be manifestly present for days and even weeks.

The repulsion effect will always be in proportion to the volume of the charges; and it is most instructive to note that, after they have been once similarly surcharged, and while the surcharges remain, the repulsion effect will persist though one of them be more heavily charged than the other. Finally, in complete proof of the tendency to persist as a separate body, if the proper test be made, after the balloons have been forced into contact, they will repel each other as soon as released, and the one to which the larger charge was imparted will be found to still retain a larger charge than the other.

This integrative trait, hereafter to be explained, appears to be a sort of worldliness, an affinity for material things. For every different electric volume carries along with it all the matter it involves or is capable of snatching from neighboring masses. This accounts for an infinite number of chemical, physical, meteorological, and astronomical phenomena which, though not wholly due to electricity, could never occur without it. The analogy suggested is interesting and goes a long way and in many directions.

The material atoms in the air, though individually small and given to levity, are the richest of all matter in electric supply. As "to

him that hath, more shall be given," all solids are perpetually giving up to the air, in the process of sublimation, and all liquids are continually yielding up to the air, in the process of evaporation, innumerable atoms of their material substance, and also with them an infinite number of little contributions to the electric wealth of the atmosphere. Aqueous acidulated solutions, being richer in electricity, filch anions of matter from metals immersed in them; and the filching process will be hastened by increasing the volume of electricity at the anode or entrance point of the inflowing charge. The anions—little corpuscles of electricity embracing atoms or molecules of matter—traverse the solution towards the cathode, carrying with them their booty. In a way similar to this, vast bodies of surcharged air migrate from the equatorial regions; or, to speak more accurately, vast volumes of electricity, embracing the atmospheric matter, carry it with them at the gait of breezes, winds, and storms. At the same time, and in the same manner, the vaporous matter in the air, invisible to the eyes, and in the more condensed form of clouds, is dragged along across the heavens, suffering many pullings, and haulings, and rendings, and redistributions as it goes, apparently as the result of the grasping disposition of electric

bodies in the less vaporous regions of the air. That there are such bodies admits of very satisfactory proof, which will be given hereafter.

That the matter in comets, negligible in comparison to the volumes of their atmospheres, by which is meant the gases that surround and attend the nuclei of all comets, is made to traverse the outlying regions of the ether of space, is suggested by the foregoing, and the probabilities of this are strengthened by several other considerations. Besides, if comets are thus influenced, so are planets of all dimensions, and also all suns throughout the universe. For, as has been well said, astronomy is but chemistry and physics operating in a wider field.

Finally, it is evident without argument that these movements throughout the universe are purposeless and meaningless apart from the operations of life. The forms that are produced by Life are indispensable parts of the universal scheme. All the familiar and constantly occurring miracles of Life are being performed in the cryptic recesses of the secret chamber of Nature, where electricity and the ether are the nimble and trustworthy household servants that are ever ready to "fill the water-pots with water," and then to "carry to the governor of the feast." Heretofore, though

the problem of how Life generates or acquires power to transform and reconstruct matter into the cells, and tissues, and organs, and forms which it weaves, is far beyond the attainments of speculative philosophy, nothing else is more certain than that, in the exercise of this marvelous power, it works its wonders always in harmony and in co-operation with these subtile, nimble, ever-present servants of Nature. It is not too much to say that it performs them invariably with their help.

It has been suggested that electricity is nothing else than ether vortices. The late Lord Kelvin, who was Sir Wm. Thompson, was the ablest advocate, if not the suggester, of this hypothesis. The famous English physicist, Michael Faraday, called the ordinary charge of a monad atom an *ionic* charge. The atom with its charge became an *ion.* Lord Kelvin estimated the volume of an ionic charge to be about one hundred thousandth of an atom's dimension, and Dr. Johnstone Stoney, conceiving the idea that it may exist apart from its material nucleus, named it the *electron.* Whether it can so exist or not, the electron is now considered the smallest conceivable volume of the essence. But whether it is a mere eddy or whirl in the ether around the atom, or within the atomic framework of the molecule, or is

an essence distinct from the ether, remains an open question with the most advanced physicists, as has been previously stated.

To this conception, which is essentially one with the notion that all the material elements are but forms of the ether, there are a few objections which would have to be answered satisfactorily before the hypothesis could be established. (1) The ether being essentially as potential now as at any former time, and being even more agitated into "billows," "whirls," "knots," and "vortices," by the countless suns in the universe, there would appear to be no good reason for its failure to continually increase the quantity of the known elements, and no reason why we should not continually witness the arrival on the planet of new kinks and new crinkles recognizable as matter. (2) A "whirl" in any fluid or mass requires a change of angular momentum. This in turn requires resistance at some point in the mass, while some force is being applied at a different point in the mass. If merely the inertia of the ether afforded the resistance, the ether having no parts or particles such as atoms and molecules, the hypothesis would have to furnish an explanation of the regularity characterizing the size and the intensities of the eighty several sorts of "whirls," as exhibited in the Periodic

Law. It would need to give an account of the fact that many of the elements differ from one another in atomic weight by the weight of an atom of helium, and for the approximation of the atomic weights to whole numbers. (3) It has been shown above that electric bodies tend to persist, in contact with one another even; but experiment furnishes no persistence of integrity, nor of the lagging which Professor Ewing calls *hysteresis,* at all comparable to the permanence of the "whirls," "knots," "kinks," and "twists" which, according to the hypothesis, constitute the material elements. An explanation of this permanence must be embodied in the doctrine of the etheric origin of matter.

There is one view of the problem in which none of these objections will hold good against the conception that the ether and electricity are essentially identical. If atoms and molecules oppose the resistance needed to produce etheric "knots," "whirls," and "vortices," then these "twists" and all that—which would occur only in connection with matter—may be what we call electricity. This would account for its clinging to matter, and for many curious facts discovered in experiments with so-called "radio-active substances." But even in this view, a separate word would be still necessary to indicate that this particular condition of the ether

is connoted, just as the word *ice* is needed to signify frozen water.

In the succeeding pages electricity will be regarded as a distinct essence, since we know that it exists, and are without proof of its essential identity with any other essence. Whatever future investigation may reveal, the proofs of its existence as a real agent in Nature appear at present to be thoroughly conclusive.

III.

The Atmosphere.

The word *air,* derived from the Greek word *aemi,* to breathe, signifies what we inhale. It is noncommittal as to the ingredient elements of the fluid. *Atmosphere,* derived from *atmos* and *sphaira,* means the *sphere of vapors,* and is similarly noncommittal; for it is not the sphere consisting of vapors, but the sphere wherein vapors are suspended. Had the nature of the fluid been better understood when a descriptive name was being devised, it might have been called *atomosphere;* for it is not only a sphere where atoms are suspended, but a sphere consisting of atomic spheres. This is none the less true in consideration of the fact that the atoms of the atmospheric gases are combined into groups as molecules.

As preliminary to a discussion of the structure and the functions of the atmosphere, it is necessary to consider its ingredient elements. Fortunately for the investigators of this age, all of these have been profoundly studied in the light of innumerable experiments by the most astute physicists of the past two hundred

and fifty years. The history of these experiments and of the several hypotheses which mark the steps of advance in knowledge concerning them, would fill a large volume.

During the latter half of the seventeenth century, before it was known that the air consists of several different gases, Robert Boyle, in England, and Edme Mariotte, in France, made the first discovery of notable value in the development of the science of gases. They found by experimental tests that so long as the mass of a gas remains constant, the temperature remaining unchanged, the product of the pressure by the volume of the gas will be approximately constant. That is, if the mass at any given pressure be doubled, the volume will be doubled; and that, if the pressure be then doubled, the whole will be restored to the unit volume.

Approximately a century later, Daniel Bernoulli suggested that the pressure of a gas against the walls of its container is due to the impact of its molecules against the walls of the vessel; and in 1848 James Prescott Joule showed what the speed of the bombarding molecules would have to be, to produce the pressure observed in certain gases. This is the genesis of what is known as the Kinetic Theory of Gases. It was developed into its present form

by the German physicist, Rudolph Clausius, and his English contemporary, Clerk-Maxwell.

For fully a century and a quarter, from about the time of the death of Oliver Cromwell till the French Revolution, or from the active period in the life of Robert Boyle till the close of Lavoisier's career, scientists groped with no other light to guide them in the study of the atmosphere than a few untenable hypotheses. Not even the word *gas,* in the sense in which we use it, was known to Boyle, though what is called Boyle's Law of Gases is now found in every work on physics. Those early investigators talked and wrote of sundry sorts of "airs," but not of gases. They supposed the atmosphere to consist of many exhalations of substances on the earth, in which supposition they were not wholly wrong; but, in trying to discriminate, they invented "phlogiston," "phlogisticated air," "dephlogisticated air," "mephitic air," and "vital air," all different from "common air."

Dr. John Mayow, of London, a contemporary of Sir Isaac Newton, advanced a hypothesis for which he should have received far more attention and more credit. It was that the atmosphere consists of nitro-aerial particles and of air particles. He was right in finding in it two elements, and also in the surmise that one

of them is nitrous. Boyle did not accept his opinion. George Earnest Stahl, a Bavarian, near the end of the first quarter of the eighteenth century, invented phlogiston, an imaginary element of the air; and this invention held its ground, as a working basis, till near the end of the century. Thereafter Mayow's new air, which had come to be called "vital air," became "dephlogisticated air."

The Rev. Stephen Hale, an Englishman and an ardent enthusiast, was one of the most industrious of the investigators of this period. As an amateur, he studied the air and distilled gases from many different animal and vegetable substances, to produce the various sorts of known "airs"; but he failed to study the properties of the gases he produced, and was content with the conclusion that "our atmosphere is a chaos." Of course, he left the subject in a very chaotic state.

During the latter half of the eighteenth century and the first half of the nineteenth, there were a dozen or more of very distinguished investigators in this field. Of these, Joseph Black, Scottish, in the University of Glasgow; Daniel Rutherford, Black's pupil; the Rev. Joseph Priestly, English, of Fieldhead near Leeds; Carl Wilhelm Scheele, Swedish, of Stralsund; John Dalton, English, of Eagle-

field; Joseph Louis Gay-Lussac, French, of St. Bernard Le Hoblat; Henry Cavendish, English, of London, and Antoine Auguste Lavoisier, French, of Paris, were the chief. All these, except Lavoisier, continued to be enslaved under the spell of "scientific authority," and displayed in their writings all the "airs" of the previous century, including *phlogiston.*

Black discriminated between "fixed air," "vital air," and "common air." But his experiments and explanations show that he was dealing with carbon dioxid, oxygen, and the atmosphere. He believed the "vital air"—distinguished by Mayow from his nitrous air—to be "the principle of inflammability," which clearly identifies it with oxygen.

Rutherford, at Black's suggestion, made investigations of the recognized *"airs"* that led him to the discovery of hydrogen; which shows that they were dealing incidentally with the aqueous vapors in the atmosphere, and accounts for their errors and confusion of ideas. Priestly weighed the several "airs," nitrous, phlogisticated, dephlogisticated, and common; and he even ventured to breathe oxygen, which, though still wearing the name of "dephlogisticated air," did him no harm. Dalton found that the total pressure of a mixture of gases is equal to the sum of the pressures exerted by each of them

separately in a given space. He propounded the Atomic Theory about the beginning of the nineteenth century. Scheele pointed out that the different kinds of "air" retain elasticity at all then-known temperatures for gases, and that they are expanded by heat and contracted by cold. Like Black, he found himself baffled by their escape in unaccountable ways; for at that time it was not known that gases are absorbed by both solids and liquids, or that they combine to form compound substances, as carbon dioxid.

Cavendish stumbled over the truth and permitted it to escape him in a remarkable way. He said that "dephlogisticated air is only water deprived of phlogiston and inflammable air"; and, again, that "phlogisticated air appears to be nothing else than the nitrous acid united to phlogiston; for, when niter is deflagrated with charcoal, the acid is converted almost entirely into this kind of air." These statements are translated into modern phraseology by Professor William Ramsay, of University College, London, thus: "Nitrogen is nothing else than nitric acid deprived of oxygen."

Just before the French Revolution snuffed out his valuable life, Lavoisier brought order out of all this chaos. He repudiated the phlogiston hypothesis, invented the name *oxygen,*

deriving it from Greek words that mean *acid-producing,* ascribed to the several gases of the atmosphere their proper places, and laid the foundation for a more satisfactory nomenclature.

Near the beginning of the nineteenth century, Gay-Lussac verified the "Law of Charles," that the volume of a given mass of any gas varies directly as the absolute temperature of the gas, if the pressure remains constant, a proposition which is deducible from Boyle's Law. He made the observation also that gases of all kinds combine with each other in very simple, definite proportions.

Count Amadeo Avogadro, the noted Italian chemist, set forth an hypothesis which has ever since greatly influenced physicists in reaching their conclusions touching atomic and molecular weights and volumes, and their numerical relations in all forms of matter. It is that equal volumes of gases, at equal temperature and pressure, contain equal numbers of molecules. This harmonizes with the apparent sameness of structure of all gases; and, therefore, with all the so-called "Gas Laws." This hypothesis led on to the Kinetic Theory of Gases, which was suggested by Bernoulli, as has been already mentioned, and which, as developed by Clausius and Maxwell, incorpor-

ates this with several other hypotheses that rest merely on theory. These are, (1) that gas particles are identical with chemical molecules, which may consist of one or more atoms; (2) that they are hard, smooth, elastic, but almost incompressible spheres; (3) that they possess an energy of translation, and are constantly in swift motion; (4) that they move always in straight lines, being uninfluenced by attraction or repulsion in passing one another; (5) that they are frequently in collision with one another and with the walls of their containers, but do not in this manner suffer any loss of their energy of translation; and (6) that they are more frequently in collision when gases are condensed.

Scheele, who independently discovered ammonia, found traces of this element in the air, a conclusion which has been abundantly confirmed. Argon, the last element to be discovered, was segregated, studied, and named by Professor William Ramsay in collaboration with Lord Rayleigh, as late as 1894. The failure of their numerous attempts to induce the new element to enter into chemical combination with any other, led them to give it the name, which is derived from the Greek negative particle *a* and *ergon,* work; for they couldn't make it work! Yet, on general principles, we may

safely presume to say that it is not an *idle* element. Just before the end of the century, Ramsay and Travers reported the discovery of "krypton," "neon," and "metargon," all of which were—as the name of the last implies—associated with argon. The same year, 1898, Professor George Jarvis Brush announced the finding of the latest claimant as a constituent of the atmosphere, which he called "etheron." Its chief characteristic is "its enormous heat-conducting capacity."

Thus, after two and a half centuries of industrious and intelligent research, the problem as to what are the essential material elements of the air has at last been solved; and the conclusion has been reached that it consists of oxygen, nitrogen, and argon, in the following proportions: in volume, oxygen 21, nitrogen 78, and argon 1; in weight, oxygen 23, nitrogen 75.66, and argon 1.34. For, though vapors of water and of ammonia, dust of iron and of other minerals, and molecules of the constituent gases in modified forms, are found in the atmosphere, these are considered as being held in suspension by the air, rather than essentially characteristic of it. However, as the word "atmosphere" denotes the gaseous envelope of the earth as a whole, and especially since it is a mechanical mixture and not a chemical com-

pound, all the incidental elements must be regarded as parts of the atmosphere, though not of the essence of the air. The distinction may be rather nice than useful. Yet, every one knows that there is a difference worth while to observe between the atmosphere of living-rooms and pure air.

The knowledge that air can be reduced to the liquid state was long deferred. Van Helmont, who was first to apply the word *gas* to aeriform matter and first to discriminate between gases and vapors, affirmed that the former can be reduced to liquids and denied that the latter can be. In a text-book on chemistry, published in 1731, Herman Boerhave, the Dutch chemist, makes the same denial in such language as to show that he, or some one within his knowledge, had attempted the reduction by submitting air to a pressure of "forty degrees greater than nature has ever been known to produce." He further asserted that the elasticity of the air can not be destroyed. On the other hand, he believed there is no limit to its capability of expansion.

Actual results began to be accomplished in the way of liquefying gases about the beginning of the eighteenth century. Experiments of several chemists resulted in liquefication; but the difficulties in the way of obtaining perfect-

ly dry gases, considered in connection with the imperfect methods of the time, led later investigators to suppose that associated vapors instead of the gases were reduced to liquids. These doubtful results were obtained by Fourcroy, Vanquelin, and Guyton de Morveau, experimenting with ammonia gas; by Stromeyer with arsenic gas; by Monge and Clouet with sulphurous acid gas; and by Northmore with chlorine and hydrochloric acid gases. Then unquestionable results were obtained by Natterer, whose experiments extended through a quarter of a century prior to 1844, with carbonic and nitrous oxide; by Sir Humphrey Davy and Michael Faraday, in the early part of this period, with hydrate of chlorine; and by Bussy with ammonia, chlorine, and cyanogen, only a little later. Further progress was made during this period, especially through the improvements in apparatus for compressing gases, by Natterer, Thilorier, and others.

In 1845, Faraday, encouraged by what had been accomplished, and having a desire to see oxygen, hydrogen, nitrogen, and other subtile material elements, in the form of liquids and possibly in solid forms, attacked the problem with all the energy of his great intellect and with all the means at his command. He summarized his work in a single sentence: "Thus,

though as yet I have not condensed oxygen, hydrogen, or nitrogen, the original objects of my pursuit, I have added six substances, usually gaseous, to the list of those that could previously be shown in the liquid state, and have reduced seven to the solid form."

Not only did these experiments foreshadow the liquefying and solidifying of the so-called permanent gases, at first dimly and later very distinctly, but they suggested and revealed so many new truths about the constitution of matter as to stimulate scientific interest, and to hasten the time of the acomplishment of all that had been attempted, and very much more.

On the second day of December, 1877, Louis Cailletet succeeded in liquefying oxygen and carbon monoxide at Chatillon-sur-Seine; and just twenty days later Raoul Pictet, quite independently and without knowledge of Cailletet's accomplishment, liquefied oxygen in Geneva. The liquefying of nitrogen, and then of the air as such, was shortly afterwards accomplished by Cailletet. Argon was not then known; but it was, without reasonable doubt, liquefied in the latter experiment. However, it was separately reduced to a liquid by Olszewski in 1898, or within a year after its discovery.

Besides the facts enumerated, the experi-

ments which brought them to light also revealed incidentally a vast amount of truth as to the relation of the ether and of electricity to the constitution and the variable forms of material substances; and such of these incidental discoveries as will be most helpful in the present study may be briefly mentioned.

Near the end of the first quarter of the nineteenth century, Cagnaird de la Tour, after repeated experiments with liquids in heated tubes, drew attention to the fact that sulphureous ether vaporizes completely in a space less than three times the volume of the liquid. That ether begins to vaporize at 150 degrees, and the liquid disappears at the same temperature without regard to pressure, suggesting the idea that there is a temperature for each liquid above which it will invariably change to vapor, other conditions favoring.

Near the middle of the century, Professor Thomas Andrews, at Glasgow, studied the subject of critical temperatures and pressures thoroughly, and arrived at the definite conclusion, now accepted by all physicists, that to condense any gas into a liquid, its temperature must be brought below a certain point peculiar to it, and that the pressure to which it is subjected must rise above a certain value for each particular temperature. He showed the liquid

state of matter to be a link between the solid and the gaseous states.

The tendency of all scientific inquiry into the nature and structure of material substances has been towards the conclusion that all sorts of matter may exist in the forms of solids, liquids, and gases, and that the continuance of any sort of matter in any of these forms depends upon conditions of temperature, pressure, and stress. The systematic study of the atmosphere has fully confirmed this conclusion. But it is of the utmost importance to remember that every sort of material substance retains its essential characteristics always in whichever form it appears.

Spectroscopic examination of different gases reveals, by showing different colors of light to be reflected by them, that their particles of matter behave in some sense differently under the action of ether waves; or else, that the ether is affected differently by the different gaseous particles. The visual transparency of the atmosphere is variable on this account.

There are two extremes of temperature between which chemical changes take place, and within which they do not occur. For instance, Dewar has pointed out that "at a temperature of —200 degrees, the molecules of matter seem to be drawing near to what might

be called 'the death of matter' so far as chemical action is concerned." On the other hand, there is a critical point of high temperature at which dissociation takes place. But, since heat results from ether agitations, which are communicated to matter through electricity, the facts point to necessary relations between these essences and the widely dispersed particles of gaseous matter. We may conclude, then, that chemical action at the highest point of these extremes is impossible, because electro-etheric agitation is too violent to permit chemical combinations, and that it is impossible at the lowest point, because there electro-etheric commotion is too feeble to rend atoms from atoms, and to reconstruct them into new forms.

But, with reference to the three forms, solids, liquids, and gases, the atmospheric gases are the most permanent; for, in the natural freedom from other pressure than that of gravity, they exist without change in the lowest temperatures experienced by the solids of the planet, and in heat that changes many solids into liquids and many liquids into vapors, being adapted to polar and equatorial temperatures.

It may be said, then, by way of giving a provisional description of the atmosphere, that it consists of that portion of the matter of the planet which is in the most dispersed condi-

tion, called gas, and is distributed with approximate uniformity over the globe. That the mean pressure of this matter on the solids and liquids of the earth at sea-level is about fifteen pounds per square inch of the planet's surface, a pressure which gradually diminishes as the surface of the fluid is approached.

The different elements which compose the atmosphere are variable in quantity, and are actually distributed differently, over the face of the planet. Robert Wilhelm Bunsen, in 1848, proved by tests of samples of air taken from widely separated localities, that oxygen and nitrogen are not always found in exactly the same proportions in the air. Exhalation from vegetable and animal substances varies as the distribution of plants and animals varies. Aqueous vapors are more abundant over seas than over deserts. Sublimates from solids are abundant over continents, and less so over oceans. Everywhere the heaviest elements tend toward the earth by gravity, and the lighter towards the upper regions of the air. But, by convection, which is the transference of essences incidentally by the movements of that by which they are held in suspension, all these different elements are shifted continually throughout the atmospheric envelope of the globe.

This brief but general view of the atmosphere is intended merely to prepare the way for an intelligent interest in the discussion of its structure and of its functions in the scheme of Nature, which is to follow in the succeeding chapter.

IV.

Structure of the Atmosphere.

The scope of this chapter might as well embrace the structure of gases as gases; for all kinds of matter in this form obey the same general laws. But in the study being pursued there is a special reason for keeping the atmosphere as such in view. Consisting of one of the three chief forms of matter, and being the integument of the planet, the buffer between the body of the planet and other worlds, an inquiry into its general functions is legitimate, especially in this study of a certain vital dominance.

Since the time of Daniel Bernoulli, the problem of how the distribution of the material particles of the atmosphere is maintained, has been studied with profound interest; and, though the Kinetic Theory of it is now very generally accepted, scientists in referring to the theory usually remind their hearers and readers that it is only a working hypothesis. These reminders come mostly in such phrases as, "According to the Kinetic Theory of Gases," and they show that the physicists and philoso-

phers are not yet fully convinced that it is the true explanation. Its assumptions, which are enumerated on page 68 in the preceding chapter, are such as to strain the credulity even of scientists.

The assumption that ultramicroscopic particles of matter possess "energy of translation," specifically contradicts the doctrine of the inertia of matter, and broadly contradicts the doctrine of the uniformity of Nature in her operations. One may well ask, How is the energy of translation imparted to matter by reducing its mass? And, Why is there not a law, that the energy of translation increases as the mass diminishes? Besides, the assumption that the molecular energy of translation is not diminished by collisions between molecules, is contrary to all our experience with "hard, smooth, elastic, and almost incompressible spheres" in larger masses. According to the doctrine of the Conservation of Energy, any other moving masses of matter in collision would give up some of their "energy of translation" to reappear in the "energy of heat" resulting from the collisions.

The assumption that the molecules of gases move always in straight lines, and that they are not influenced by attraction or repulsion in passing one another, contradicts Newton's

great proposition of the *Principia,* that every particle of matter attracts every other particle and is attracted by every other particle with a force depending only on the product of the masses and the square of their distances. Besides, if there is a law of repulsion which is not yet fully understood, as has been suggested in connection with the study of comets, it also is set at naught by this assumption.

Over against these hypotheses of the Kinetic Theory, which, to say the least, are very questionable, a number of facts, that have been fully established by oft-repeated and carefully observed experiments, may now be set forth to lay the foundation for an explanation which involves no such contradictions.

Some of these facts have already been mentioned, but they may be briefly repeated. The long known interstitial separateness of atoms and molecules of even the most condensed matter suggests a starting-point. The smallest of electric charges, the electrons, occupy the interstices. No particle of matter can be denuded of its subtile integument. This, however, may be vastly increased. It tends to a spheroidal form. It affects, and is affected by, ether agitations. It accumulates where etheric commotions occur.

The three chief forms of matter, the solid,

the liquid, and the gaseous, depend on temperature; and this is equal to saying that they depend on the amount and kinds of ether agitation (apprehended by the senses, as heat) in which they exist. They merely represent three degrees of molecular separation, and the cause of separation is the same in each degree.

Mr. John Tyndall, in his work entitled *Heat as a Mode of Motion,* expresses this view in the following language in the early part of his third lecture:

"By the force of cohesion, then, the particles (of solids) are held together; by the force of heat they are pushed asunder; here are two antagonistic principles on which the molecular aggregation of the body depends . . . every increment of heat pushes the particles more widely apart; but the force of cohesion . . . acts more and more feebly, as the distance between particles, which are the seat of the force, is augmented. As, therefore, the heat strengthens, its opponent grows weak, until finally the particles are so far loosened from the rigid thrall of cohesion, that they are at liberty, not only to vibrate to and fro across a fixed position, but also to roll or glide around each other. Cohesion is not yet destroyed, but it is so far modified that while the particles still offer resistance to being torn directly asunder, their lateral

mobility over each other's surface is secured. *This is the liquid condition of matter.*

"In the interior of a mass of liquid the motion of every atom is controlled by the atoms which surround it. But suppose you develop heat of sufficient power within the body of liquid, what occurs? Why, the particles break the last fetters of cohesion, and fly asunder to form bubbles of vapor. If one of the surfaces of the liquid be quite free, that is to say, uncontrolled either by a liquid or solid, it is quite easy to conceive that some of the vibrating superficial particles will be jerked quite away from the liquid, and fly with a certain velocity through space. Thus, *freed from the influence of cohesion, we have matter in the vaporous or gaseous form.*"

Here Mr. Tyndall tacitly accepts the Kinetic Theory, implying that there are molecular vibrations still in the liquid as there had been in the solid, and the flying of particles of vapors and gases through space. But the quotation states very specifically and clearly the conception that solids, liquids, and vaporous or gaseous states of matter are but different degrees of separation of their molecules. Besides, its chief purpose is to maintain that heat is the occasion of the pushing asunder in each degree of separation. But he knew, and has testified

quite as clearly, that heat is attended by, and also caused by, agitations of the ether. Similar testimony might be taken from any other distinguished modern philosopher; but Mr. Tyndall's statements happen to be in a form most convenient for the present purpose. In his eighth lecture, of the volume quoted above, he says:

"You must therefore figure the particles of the heated body as being in a state of motion; you must figure the motion communicated to the surrounding ether, and transmitted through the ether with a velocity which we have the strongest reason for believing is the same as that of light. Thus when you turn towards a fire on a cold day, and expose your chilled hands to its influence, the warmth that you feel is due to the impact of these ethereal billows upon your skin."

Again, in the tenth lecture, after enlarging upon the radiation and absorption of heat effects by different gases, he says with striking pertinency to the matter in hand:

"We see that radiation and absorption go hand in hand; that the molecule which shows itself competent to *intercept* a calorific flux, shows itself competent, in a proportional degree, to generate a calorific flux. That, in short, a capacity to accept motion from the ether, and

to impart motion to the ether, by gaseous bodies, are correlative properties."

Though you may not be able to take *immediately* "the impact of these ethereal billows upon your skin," for the reason that the electric envelope covering every cell of flesh would prevent it, you can perceive the great physicist's observed effects literally; and, mentally, you can apprehend his idea of the relation between the ether and temperature; and his ideas pass at par with nearly all our scientists.

Keeping in mind that what "ethereal billows" and electric charges do with atoms and molecules, they also do with larger masses of matter in innumerable instances, a surprising group of phenomena may here be introduced as witnesses. They are of the class known as "Leidenfrost's Experiment."

Heat an aluminum ladle or pan and let a few drops of water fall on it, and they will behave like particles of mercury, assuming without hissing or loss of volume the spheroidal form. When they collide they will merge into one sphere readily, but will exhibit a slight degree of aloofness. They show a tremulous excitement during the ordeal. Remove the ladle from the fire, and when it cools sufficiently the water will evaporate, sending up a little cloud of vapor.

Heat a platinum ladle to redness and pour into it a little liquid sulphur dioxide from a tube that has been chilled in ice and salt for a half hour. The liquid will behave as did the water. Now drop a little water on it from a pipette, and at once remove the spheroid from the red-hot ladle into a cool container. It will be a ball of ice! The lesson ought to be as great as the surprise. M. Boutigny was the first to do this experiment; but he got the notion of it from Leidenfrost. Faraday froze mercury in a red-hot ladle by using solid carbonic acid.

M. Boutigny thrust his hands into molten iron and molten lead after wetting them in cold water. Blacksmiths have been seen to touch red-hot iron with their tongues, and housewives to test the heat of sad-irons with their fingers moistened by spittle.

Toss a dipper of water upon a floor that is covered with dry dust, and little spheroids of water will be seen to roll over the dust. Sprinkle fine flour on the surface of water and witness it float without being wetted. Cover the surface of a plant-bed with dry dust after watering, and find that the water will not soon evaporate, its vapor not being able to escape through the dust.

Notice thoughtfully the quantities of limestone and other road-making materials, in the

form of dry dust, that rise and float away on the breezes when disturbed by the feet of horses and the wheels of vehicles. Especially observe how the tiny particles of stone keep aloof from one another as they fly!

The levity of limestone in this condition can not be accounted for by the action of breezes, though atmospheric currents may carry it far above the earth. If the air of a room be permeated with the dust of calcium, the dust will be found to settle continuously for several days, though the air in the room be kept perfectly quiet. The same would be true of any other kind of fine dry dust. Even tons of dust from volcanoes have been known to continue afloat in the atmosphere, manifesting itself by diminishing the transparency of the air, for weeks at a time. The particles of dust thus afloat in the atmosphere are distributed uniformly in a manner analogous to the distribution of the molecules of a gas, although their separation is not maintained by mutual bombardment, as every one knows.

Another class of facts, whose bearing on the problem will be seen clearly hereafter, are those which relate to chemical avidity, or the "appetite" with which acids devour bases. Still another class, whose bearing will be more readily perceived, are the interesting and hither-

to unexplained phenomena of osmotic pressure. The facts here referred to are too numerous to be set down in detail; but every chemist knows that the study of the avidity of acids is a consideration of how bases distribute their particles between different acids that happen to be contending for them. Also, every physicist knows that all osmotic phenomena involve certain instances of the distribution of atoms and molecules of liquids and gases which appear to be against gravity. Only one of the innumerable instances of each need now to be given.

When equivalent quantities of sulphuric and hydrochloric acids contend for the particles of a base that is sufficient to neutralize only one of the acids, the hydrochloric acid gets two-thirds of them and the sulphuric acid one-third. Chemists say the avidity of the hydrochloric acid is the greater. It will be worth while to remember in this connection that "hunger" is the chief occasion of "appetite" and of devouring with "avidity."

Take a solution of copper sulphate and place it at the bottom of a cylinder, and then cover it with a layer of pure water, and the color of the copper sulphate solution will be seen to gradually rise through the water from a region of greater to a region of less concen-

tration. This is apparently against gravity; for the concentrated copper sulphate solution has a much higher specific gravity than the water through which it ascends. At the same time, of course, some of the water descends, in spite of its comparative levity.

Take a clear glass vessel whose contents are the atmospheric gases, and introduce at the bottom of the vessel a volume of the vapor of bromine, which is a colored gas. Here, again, a diffusion apparently against gravity will proceed till the transparency of the air gives place to a color approximately that of the bromine gas. The same thing would occur with a transparent gas, of course.

This kind of diffusion has been studied by causing fluids and gases to push through the walls of porous vessels, and through porous partitions across single vessels; and hence the observed phenomenon is called osmosis, from a Greek word which means to push. But the pushing takes place wherever the solutions of dissolved bases and solvents are brought together, and also wherever different gases are mixed. The advance toward complete diffusion is in both cases facilitated by heat and in most cases proportional to the concentration.

All the facts of so-called "surface tension" and of "capillary," and very many others, might

be embraced in the induction; for this is a case of the need to know something of everything in order to understand anything. But it is hoped that a sufficient number and variety of instances have been mentioned to clearly illustrate the main points in an explanation of the structure of the atmosphere.

There is just one thread on which all these beads can be consistently strung. There is only one way in which all these phenomena can be consistently explained; and, since all truths harmonize, an explanation of any of them that is contradictory to any known truth or principle can not be the true explanation.

The problem as to the constantly wide and uniform distribution of molecular matter in the atmosphere requires satisfactory answers to the following questions: (1) How are the molecules of gas kept aloof from one another? (2) Why is their aloofness increased by heat? (3) Why is heat manifested when a gas is compressed, and why does a fall of temperature accompany its expansion? (4) Why does the aloofness of the particles of gases tend to increase, resulting in indefinite expansion and gas pressure? (5) Why do gases differ in their force of expansion, and why is the pressure of each gas a constant at unit volume and temperature? (6) Why do gases whose mole-

cules are different in weight so diffuse as to distribute the molecules of each gas uniformly throughout the container of mixed gases, as in the osmotic phenomenon? (7) Why does each gas in such mixture exhibit its pressure independently, as if no other gas were present? A principle according to which all these questions can be consistently answered will be applicable also to the related problems touching liquids and solids.

(1) Particles of matter in gases, as in liquids and solids, are kept aloof from one another by their enveloping electrical charges. The pith balls and bits of gold leaf in the electroscope stand aloof when similarly charged. Individual hairs on the head, when combed with a vulcanite comb, especially on cold days, exhibit this phenomenon. The experiment with the rubber balloons, described on page 53, shows that the apparent repulsion persists even when unlike poles of the charged bodies approach each other. The repulsion is an incidental effect. The charge arranges itself so that every part of it will be as near as possible to the center of the mass of matter involved. The spheroidal form results from this tendency. The exclusion of other like spheres follows, and the repulsion is merely commensurate with this integrative, spheroidal, exclusive tendency. The

experiment illustrates also the persistence of surface charges upon one mass in the presence of other surcharged masses. The behavior of particles of dust in the atmosphere affords another illustration of the same thing. The reasons for the clinging of electricity to matter, and for its manner of distributing itself over, about, and upon matter, must be given elsewhere.

(2) The aloofness, or expansion, is increased by heat, for the reason that heat is an effect of ethereal commotion coincident with which there is an increase of the electric charges upon the masses of matter involved in the commotion. Here Tyndall's remarks hold true, "That, in short, a capacity to accept motion from the ether, and to impart motion to the ether, by gaseous bodies, are correlative properties;" and still more pertinent is his remark "that the molecule which shows itself competent to intercept a calorific flux shows itself competent, in a proportionate degree, to generate a calorific flux." But a heat producing flux is nothing else than a clash between "ethereal billows" and the electric charges of the molecules about which he is discoursing. Everything known by electricians about "induction" and about "generating electricity" tends to show that electricity alone will move the ether; and also that, wherever there is ethereal agitation in a system,

electricity will accumulate in that system. Here, then, is the secret of the connection between temperature and expansion in all forms of matter. Expansion is an electro-ethereal effect, the result of increasing molecular electrical charges.

In the strictest sense, the sun does not transmit heat to the earth. It starts ether undulations which traverse the space between the sun and the planets as undulations or waves, not as heat. When these waves impinge upon electrically charged matter, those clashes occur which make themselves known to us as heat. If it be true—or claimed to be true—that electricity is nothing else than the swirl of the ether about atoms and molecules, it still follows that these whirls are increased by ethereal commotion and that the particles of the air are in this manner set aloof from one another. Molecular motion is not due to "an energy of translation" inherent in matter; nor is it the essential thing in the function of matter where heat is produced. The essential thing is the competency of the atom or the molecule to receive the impact of the ether waves. Electricity is the buffer which Nature has provided to protect the organic forms of matter from the distress of ethereal commotion; and she has made the further necessary provision that,

wherever the commotion is increased, the protecting integument shall be simultaneously increased, adjacent charged elements furnishing the needed supply.

(3) In harmony with its function, and its well-known behavior in all experiments with electricity—if not, indeed, on account of its nature, as intimated above—electric surcharges deploy themselves on the surface of matter. But compression, of gases especially, diminishes available surface for the presence of surcharges. For instance, a cubical block one foot in each of its dimensions exposes 864 square inches of surface; but if it be divided into blocks containing each a cubic inch of the substance, 10.368 square inches of surface will be exposed. Fancy how prodigiously the surface exposure would be increased if the substance were so divided that each face exposure would be one-millionth of an ultramicroscopic line one inch in length! Now, since electricity acts like an incompressible gas, any pressure whatever disturbs the surcharges of the molecules of the gas under pressure, because it reduces the available surface occupied by the surcharges. The disturbance produces ether agitation, and heat is manifested; for the agitation is communicated to all adjacent matter. On the other hand, when the gas is permitted to

expand, its molecules draw on adjacent matter for their modicum of the fluid; the electricity in the adjacent matter is diminished, and so is the ether commotion of the wave-lengths which produce heat; and therefore the temperature is rapidly lowered. Evaporation produces the sensation of cold, because the vaporizing matter is appropriating electricity from all adjacent matter, whatever be its form.

Evaporation is checked and reduced to a minimum in the case of the liquid sphere on a hot ladle, for the reason that the expanding vapors about draw away electricity from its surcharges till it is chilled; and a liquid that gives up its electricity freely is frozen.

(4) In a sustained temperature the molecular charges tend to increase, and this results in expansion and pressure on the walls of the container of a gas. When free from all pressure except that of the atmosphere, the enlarging spheres push away their neighbors and in turn are pushed away towards the wider region of less pressure at the surface of the atmosphere.

(5) The several material elements differ in their capacities for receiving and holding electrical charges. This is as true of molecules as of larger masses; and, in the same environment, molecules of different elements will become sur-

charged at different rates per unit time. Then, under constant pressure and in a sustained temperature, gases of different elements will be composed of charges of different volumes. The electric spheres of each gas will increase according to the nature of the element, and will increase the pressure accordingly, no matter what other molecules may happen to be present in the container.

(6) Masses of matter having comparatively less charges attract and are attracted by masses having larger charges. Where solutions of salts of different elements are brought into contact in the form of strata, the upper stratum being of less specific gravity than the lower, the whole volume above is attracted by and attracts the whole volume beneath; and, in particular, the several molecules of the one are attracted by and attract the individual molecules of the other. Every molecule in the two strata is set in motion, these towards a center of gravity above, and those towards a center of gravity beneath. That osmose is an electrical process may be further shown by passing through the solutions an electric current. If the solutions be separated by a porous partition, a higher level by the side towards which the current flows will suggest to any thoughtful observer that the artificial electric pressure is but facilitating

what would naturally occur by the same cause, but less rapidly. Rightly understood, osmosis is not against gravity. It is only to the casual observer that it appears to be against gravity. The same causes operate to diffuse the molecules of mixed gases with like uniformity.

Now, it follows from all these considerations, first, that electricity is an essential constituent of the atmosphere; and, second, that it forms the major portion of the atmospheric volume. In fact, we are justified in thinking of this sphere as the planetary electron, or the charge that envelopes the earth as the electron envelopes the molecule. The atomized matter held in suspension by it, since it immensely increases the surface exposure of the planet's mass, affords the essence lodgings out of all proportions to the room for a foothold on the solid earth without the dispersed matter.

After all, we are tempted to call the globe's integument "the electrisphere"; but, seeing that we have attained a point from which a larger conception may be had of the functions of the atmosphere, we may take up some other notions which will render the conception clearer and more useful in the end. The reader may here be reminded with propriety of our advance toward the thesis that there is a vital factor in control of the physical world.

V.

Electrical Spheres.

The electric charge of an atom was named an *electron* as being the smallest identifiable volume of the essence; but in combination with the atom or molecule it is called an *ion;* and for larger masses of matter the word *charge* is used as a general name for the volume of electricity enveloping or traversing any given mass. It is now desirable to consider electrical bodies as individualized, and to study and to classify them. The words *ion* and *electron* having limited application by common consent, and the word *charge* carrying the notion of impartation, it is desirable to have a word which shall mean the electrical volume associated with and individualized by aggregations of molecules or any mass of matter. Henceforth, in this treatise, the word *electrisphere* will have this meaning, and will be used especially to designate the larger individualized bodies of electricity.

Already the electrispheres of dewdrops, raindrops, mercury spheroids, leaden missiles, and liquids in spheroidal form on heated surfaces, have been mentioned incidentally. Such

as these are next in the order of dimensions after electrons. But a more important difference than that of dimensions should be noted. The electron is the molecule with its envelope of pure electricity, but the electrisphere of any larger mass of matter is composed of electrons, and the electricity which envelopes the particle performs also the same service for the larger mass in numberless instances. To illustrate, the drop of liquid which takes the spheroidal form on the red-hot ladle is enveloped by the electrons of the gases escaping from the heated metal, and by the electrons of vapor developed from the drop itself. They cling to it because it is the nearest mass of matter whose potential is different from their own, and from which an increase of volume is available. In arranging themselves every one as near as possible to the heart of the drop, they give it the spheroidal form, as has before been pointed out. Thus the electrisphere is an aggregation of electrons.

Physicists usually treat these phenomena under the head of "surface tension" and "capillary attraction." The current explanation of the phenomena is given in the profound and meaningless aphorism, "The potential energy of a system of bodies at rest tends to a minimum." Meaningless, that is, to all except

scientific specialists. Since the times of Galileo and Newton—the latter was born in 1642, the year the former died—philosophers have steered away from the consideration of the specific causes of motion, for reasons which appear to them to be of special importance to physical science. First, whatever be the cause of motion in any given case, the active agent always has the same effect—it changes momentum. Then, by the use of such terms as "energy," "force," and "torque," to connote the cause in a general sense, all speculation and all difficult questions as to the nature of particular causes, are eliminated. The convenience of this has led on, during nearly three hundred years, to the upbuilding of a consistent and beautiful aggregation of words, phrases, and so-called "laws," the learning of which is called education; but, since it often happens that there is nothing in Nature to correspond to these terms, phrases, and laws, vast multitudes of students go out from colleges far better equipped with the terminology of philosophy than with correct ideas of the realities about which the sciences and philosophy are concerned.

No body or system of bodies of matter has any sort of energy *per se.* Apart from some *vis a fronte* or *vis a tergo,* no body or system of bodies ever *tends* to a minimum, nor to a

maximum, nor to anything else. There is no such thing in the physical world as "surface tension," nor as "surface energy" as a property of matter. There is no species of "attraction" that operates only in small orifices. The attraction that causes a liquid to rise in a capillary tube is the same as that which shaped the planets into spheres.

That every plant, every animal, and every distinct body of matter is enveloped by an electrisphere which is individualized in its association with the object it envelopes, admits of proof by a myriad of experiments. The leaves and the branches of trees distribute themselves in free spaces by the repression of neighboring leaves and branches; vines are inclined and directed to supports by the electrispheres of objects in their vicinity; and even persons are sometimes made conscious of the presence of others by this subtile contact. Thus, by means of this integument, every individual object is put in touch with all the other objects in its environment.

Electrispheres are individualized by or in connection with vaporous clouds, as is shown by every flash of lightning ever witnessed. When two such electrispheres approach each other, if their respective vaporous loads be in like proportion to the volume, and the two

spheres be of the same temperature, they will glide past each other in the manner of two molecules of water. If kept in contact, they would slowly merge into one electrisphere involving the total mass of vapor. But if they should differ in load or in temperature, one of two phenomena would occur, according to the extent of the differences intimated. Either a gradual and quiet equalization of molecular charges would take place, or else there would be a sudden bolt. The bolt might be so general over the surface of the vaporous mass, and so moderate in its intensity, as to produce merely a sheet of light; or, it might leap from one point of the surcharged mass towards the other, when "a streak of lightning" would be seen. In such cases, however, the two masses of vapor are drawn toward each other, and the two electrispheres are merged into one.

The presence of such electrical bodies in the atmosphere is not dependent upon visible vapors. For a most interesting illustration and convincing proof of this, which may seem to the uninitiated impossible of proof, we are indebted to the well-known English scientist, Mr. John Tyndall. Some fifty years ago he undertook to settle, by strictly scientific investigation, certain doubts and disputes in relation to the efficiency of fog-horn and gun signals to ships

off dangerous coasts. The work was undertaken in the early part of 1873, and was done jointly with the Elder Brethren of the Trinity House in the vicinity of Dover, England, along the South Foreland Cliff. This was the occasion of his remarkable discovery.

The signal station was on the cliff, two hundred and fifty feet above the sea. It was equipped with modern sirens and guns, and there were men and vessels at his disposal. Many days were spent on sea and shore, and no fewer than twenty thousand blasts from the fog-horns, and hundreds of shots from the signal guns, were let off during the test. His findings were very puzzling. At sea, the signals were inaudible in variable distances on different days. The weather, foul or fair, made not the slightest difference in the fluctuations. This was hard for Mr. Tyndall to accept, because it was at variance with the accepted notions of physicists at the time. Upon one day, at a certain bearing, the sounds would be inaudible at two and a half to three miles from shore, but would be distinctly heard by his assistants who happened to be at points six or seven miles from shore; and on other days, when perfect visual transparency of the air was expected to favor the transmission of sound-waves, not a sound could be heard at even so

short a distance as two miles from the South Foreland Cliff. Then it occurred to his astute mind that "there was something in the air"! Upon the hypothesis that this "something" had individual form and was capable of resisting and diverting sound-waves, he placed himself at the foot of the cliff; and, when the sonorous waves fell on that "something," which he called "an acoustic cloud," they came back to him in reverberations of astounding distinctness.

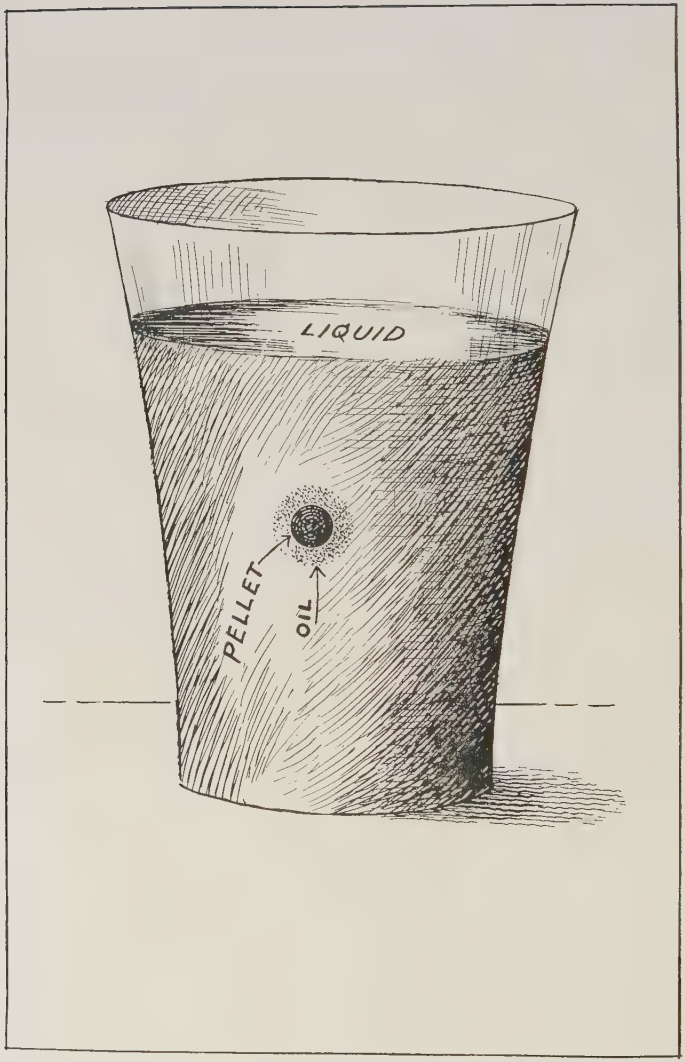
His report of the experiments, and all the grounds for his conclusion, will be found in his work on sound. He says nothing of electricity in the course of the discussion; but, since electricity is of the essence of the atmosphere, and must of necessity have its relations to undulations in the air which affect the sensorium as sound, and since it is the only agent in an approximately dry and transparent air adapted to produce such "an acoustic cloud," we may confidently assert that what Tyndall discovered was an electrisphere, which was drifting off shore along the South Foreland Cliff at the time of his observation.

Expert telescopists and spectroscopists encounter these bodies in the air, and find them to operate as lenses, and to interfere with their work. They call them "air clots" and "air lenses"; and Dr. J. Scheiner, of the Royal Astro-

physical Observatory at Potsdam, says that they are spherical. This is confirmation from learned and reliable sources; and it shows that they interfere with waves or pulses which produce light, as well as with those which produce sound. The designations, "acoustic clouds," "air clots," and "air lenses," betray the origin of these names. To the student of sound they were "acoustic," to the star-gazer they were "clots," and to the analyst of light they were "lenses." In this treatise on electricity they are "electrispheres." Possibly, after all, they are only convolutions in the ether of space. But their existence is assured beyond doubt.

Enough has been said to show what is meant by electrispheres, and to show also that they can exist and maintain individuality, even when submerged in a sea of electricity. But the greater electrispheres have a more stable individuality. The purpose of this chapter is to make the fact just stated quite evident by a study of those which envelop the several bodies that constitute the Solar System. Not that they differ in essential particulars from the electrispheres of other systems in the universe; but rather because they are nearer to us, and more accessible as objects of study.

Make a mixture of alcohol and water with sixty per cent. of the former and forty per cent.


LIQUID
PELLET
OIL

of the latter. Make a small pellet of paraffin and coat it with a dust that will counterbalance its buoyancy. Cover this pellet with a drop of oil and place it in the mixture of alcohol and water. The oil will not spread over the liquid, but the little sphere will be suspended within it, apparently freed from the influence of gravity. Now let the pellet represent the earth; the oil, the electrisphere; and the liquid, the ether of space. An idea may thus be conveyed, in a rough and general sense, of the planet's relation to the two subtile essences in which it floats, and of their relation to each other. The oil forms a perfect little sphere around the pellet, and is in touch with nothing but the liquid on its outer surface. In these respects, it is comparable to the earth's electrisphere, which envelops the whole earth and is submerged in the ether, being in touch with nothing else at its periphery. Then, there are noteworthy differences.

The atmospheric electricity, with the air itself, diffuses into the solids and liquids of the planet to a vaster extent than is commonly understood, and the elemental charges envelop every atom from the circumference to the center of the globe. Considering the whole volume, the planet is more a globe of electricity than of anything else; and this portion of its essence

is more dense than the other components. Therefore, the electric volume is not a thin shell, or film, but a dense sphere.

The great importance of this fact will be appreciated when it is recalled that the essence of which this sphere consists is the only thing connected with the planet which is immediately affected by the ethereal pulses; and that heat, light, and every mode of motion on the earth, and of the earth, depend upon these actions of the ether. If in yester years the electrisphere had been obliterated, Byron might have written as history, instead of poetry, his lines:

> "The bright sun was extinguished, and the stars
> Did wander darkling in the eternal space,
> Rayless, and pathless, and the icy earth
> Swung blind and blackening in the moonless air."

Or, rather, a catastrophe of this description would have followed, but no historian could have survived long enough to write about it.

It is evident that the portion of the electrisphere superficial to any heavenly body, is proportional to the volume of its atmosphere. It is equally obvious that, to estimate even approximately the amount of electricity associated with any body of matter, the proportions of solids and liquids contained, their density, and the amount of gases absorbed by them,

must be known. Since these things are only approximately known, nothing more than probabilities can be established as to the electrispheres of the bodies composing the Solar System. Still, enough is known to serve as grounds for reasonable conjecture concerning the volume and intensity of the several electrispheres, and for comparisons between them and the material spheres which they attend.

For instance, it is evident not only that the moon has no atmosphere, but that there are neither gases nor liquids near enough to the surface of the body in sufficient quantities to produce clouds under the influence of the rays of the sun. We may reasonably conjecture, then, that the moon's electrisphere is approximately coextensive with the solid body of the planet. The entire volume of its electric charge appears to be distributed among the molecules of its solid structure and of its internal gases and liquids, if it have any. On the contrary, comets are attended by vast volumes of gases; and from this fact we may reasonably infer that the electrisphere of any comet, being coextensive with both its atmosphere and its solid component, is proportionately larger than that of the moon. In a word, the moon is scant, while comets are abundant, in electrical supply.

A few recent writers—exploiters of what

has been styled "vaudeville science"—have asserted that all the gas attending Halley's comet could be held in a thimble! Any one who has seen the inside of a thimble has looked through its content of atmospheric gases which were under a pressure approximately ten pounds. But the gases were not visible. Anybody who has looked up through the atmospheric gases on a clear day has seen them; for the blue of the sky is due in part to the presence of the molecular matter of which the air is composed. The fact that there are molecules enough in the atmosphere of comets to reflect light to the earth, or else to be self-luminous throughout their millions of miles of extent, is a sufficient refutation of all such notions of the attenuation of their gases.

The nuclei of comets vary in diameter from one hundred miles to eight thousand miles; and the coma, or nebulous "head," so called, may be of any diameter between ten thousand miles and a million miles. All who are competent to judge of such matters are convinced that the masses of comets are to be estimated in thousands of tons, notwithstanding their very negligible influence in gravitational effects.

Admitting, however, that the material mass of comets must be small as compared to that of

the moon, it is an anomaly (if not a total disregard of the Kinetic Theory) for any comet to have an atmosphere, however greatly attenuated. For, according to this theory, gas molecules are leaping and bounding at rates of speed from fifteen hundred feet to two miles per second; and, as Dr. Johnstone Stoney, the Irish physicist, showed long ago, no free gas of low density can stay on even a planet of small mass whose temperature is comparable to that of the earth! Yet, comets carry their atmosphere out billions of miles beyond the remotest known outposts of the Solar System; and then they return with them to perihelion, where they literally fly in the face of the sun —and, figuratively, in the face of the scientists —through regions of thermal excitement that, according to Sir John Herschel, would fuse any material known on the earth. Again, having endured this ordeal, they set off for their long orbital jaunts accompanied by their gases.

Standard text-books on physics point out that, since the diameter of the moon is only one-fourth and its mass one-eightieth of that of the earth, the lightest substance the moon can retain must have a density twenty-five times that of hydrogen. The gravitational pressure is estimated to be five times greater at the earth's surface than at the surface of the moon; the

molecule's "energy of translation" is assumed to be the same everywhere; and the inference is that the moon has incontinently given up its atmospheric gases. The lunar gas molecules, by their "energy of translation," have leaped off the planet into space, exercising the freedom permitted by the feeble attraction of the moon's small mass. For the present it must suffice to say that this explanation of the moon's loss of atmosphere leaves something to be desired.

The hydrocarbons, carbon monoxid, cyanogen, and vapors of iron, are the principal gases which the spectroscope reveals to be present in comets. As meteor rings are known to coincide approximately with the orbits of comets, especially of comets that have disappeared, the conjecture that the meteorites which have fallen to the earth are fragments of comets is reasonable. These have added their testimony to that of the spectroscope; for they have yielded up gases which must have been absorbed by them from the atmospheres in which they existed before they strayed from the flocks with which they were herded in the fields of space. Spectroscopic investigation of these gases shows them to be identical with the gases of comets, so far as the latter are known. The fact that these gases were absorbed by the solid matter indicates external pressure, rather than the

"gravitational pull" of the solid as it is conceived of by those who explain how the earth retains its atmosphere, and how the moon suffered its loss.

But the point of importance to the present study is, that the difference between the moon and comets, as regards electrispheres, is shown by all these facts to be real and very wide. What has been said shows also how other like facts may be gathered and how other comparisons may be made between different bodies of the Solar System. Henceforth the facts may be given and the comparisons may be made very much more briefly.

An authoritative summary of scientific discoveries touching the atmospheres of the planets is given by Professor Dr. J. Scheiner, Assistant at the Royal Astrophysical Observatory at Potsdam, in his treatise on *Astronomical Spectroscopy*. Omitting only two incidental remarks, the summary is as follows:

"The spectroscopic observations of the planets have thus shown that they are surrounded by atmospheres, though this is not perfectly certain in the case of Mercury. The atmospheres of Mercury, Venus, and Mars show the same absorption lines as the earth's, and it is therefore probable that the atmospheres are more or less similar. It is difficult to say how

far this similarity extends; but the presence of aqueous vapors is certainly indicated, since the principal absorption lines of our atmosphere are due to it.

"The similarity of atmosphere of the inner planets and Mars is not intrinsically improbable, since the densities of these planets do not greatly vary. . . .

"The atmospheres of Jupiter and Saturn also have considerable likeness to those of the planets already mentioned—at least, as regards the occurrence of aqueous vapor. In their spectrum, however, there appears a new absorption band, the origin of which is still doubtful. It may be due either to modifications of pressure and temperature or to another gas; and in view of the atmospheres of Uranus and Neptune we should be inclined towards the second alternative.

"The two outer planets possess atmospheres certainly very different from ours, which contain large quantities of a substance foreign to our own. The fact that the band first met with in the spectrum of Jupiter also occurs in these planets indicates that the atmospheres of Jupiter and Saturn form a transition to those of Uranus and Neptune."

This author and other competent observers have pointed out a striking difference between

Venus and Mars, the two planets nearest to us. Venus, which is nearer the sun than the earth, is constantly enveloped in clouds which prevent a view of the true face of this neighbor. Its superior brightness is therefore due to reflections of sunlight from the thin upper strata of its atmosphere above the clouds. On the other hand, Mars, which is the next beyond the earth from the sun, though enveloped by a mantel of clouds, exhibits openings through which at different times different portions of his surface can be seen. Surface markings, as snow-caps at the poles and bodies of water throughout the warmer regions of the planet, send back the rays of the sun through its atmosphere, which announce this fact to us in the absorption lines of the spectroscope. But these bodies are alike in the possession of large quantities of aqueous vapor and of water.

The asteroids are a multitude of small bodies which swarm in the space between the four densest and least remote from the sun of all the planets, and the four least dense and most remote from the sun of all the planets. Within their circle are Mars, the earth, Venus, and Mercury; and without are Jupiter, Saturn, Uranus, and Neptune. They appear to form a sort of cordon between the habitable and the uninhabitable worlds of the Solar System. A few

of the larger of them have been studied spectroscopically, and they give evidence of having atmospheres. In the present state of our knowledge of them, a conjecture as to their electrispheres would have to be formed in part on grounds of general uniformity.

To get an idea of the comparative volumes of Mercury, Venus, Mars, and the earth, set down the figure 7,918 as the diameter of the earth in miles. Then subtract from this number only 218, and the remainder will be the diameter of Venus. But 3,718 must be subtracted to get the diameter of Mars, and 4,918 must be subtracted to get the diameter of Mercury. To form an idea of their comparative contents, or of the mass of each as compared to that of the earth, let 27 represent the earth's mass; 1/27th will be that of Mercury; 3/27ths will be that of Mars; and 22/27ths will be approximately that of Venus. The latter is a sister planet to the earth, then, being only a little less in volume and only one-fifth less in mass. Mercury, nearest the sun, is least of all, except the asteroids; and Mars, though farther from the sun than the earth, is in volume only one-seventh, and its surface is only about two-sevenths, of that of the earth. But there is an important difference in the density of these three planets. Mars lacks 27/100ths of being

as dense as the earth, while Venus lacks only 14/100ths. It has been estimated that her atmosphere is almost twice as dense as our own. A further point of comparsion touching Mercury relates to its behavior towards the sun as the moon towards the earth. In this, if it be the fact, it differs from all the other planets of its class.

From all these considerations it may reasonably be inferred that the electrical charges of these planets, in proportion to the matter in each of them, are larger and larger as their distance from the sun becomes greater. In brief, the volume of their electrispheres increases in proportion to the mass as their distance from the sun increases. The converse is probably the more fundamental fact; but this will be considered hereafter.

Turning now to the major planets, Jupiter, Saturn, Uranus, and Neptune, a little attention to their comparative volumes and densities will be sufficient to convince any thoughtful person that the first two of them, at least, conform to the rule indicated. The volume of Jupiter is 1,355 times that of the earth, though its density is less than one-fourth that of our planet. Its atmosphere is so heavily laden with vapors that its surface is never seen. Its albedo is sixty-three per cent., a fact which has suggested

to physicists that some of its light may be self-emitted, and that its surface may be still in a state of igneous fusion. All these things indicate an enormous dispersion of the matter of Jupiter, and therefore a vast electrisphere in proportion to the planet's mass. Though not so large in proportion to the mass as that of the comets of larger orbits, yet larger in proportion to the mass than that of any of the planets within the asteroidal circle.

Before taking up the question as to whether the rule applies to Saturn, another fact about the earth and the major planets must be noted. Jupiter is the center of a system in which there are known to be five bodies, two of them approximately the size of our moon, and one of them a third larger. Their distances from Jupiter range from 262,000 to 1,169,000 miles, being about 6, 9, 15, and 26 radii of the planet. Of course, Jupiter controls them in a gravitational sense. In studying the problem of the distribution of the primary planets, the total influence of all the electrispheres within such a system as that of Jupiter must be taken into consideration. Mars is such a center, having two small satellites; and so is the earth, having one, which is the largest in comparison with its primary of all the secondary planets of the Solar System.

Astronomers are used to dealing with these systems as units; and, in estimating gravitational effects, especially in case of the earth and the moon, the mass of the moon being so considerable in comparison with that of its primary, they dare not disregard it. No other satellite is more than one-thousandth of the mass of its primary; and some of them are so far removed from their centers that their influence may be neglected in certain calculations. In other estimates they are of great importance, as in determining the mass of planets having satellites. For instance, here is a well-known proportion, stated in words; "*The united mass of a body and its satellite* is to the united mass of another given *body and its satellite* as the *cube* of the distance of the first divided by the square of its period is to the *cube* of the distance of the second satellite divided by the square of its period."

The volume of Saturn is only 760 times that of the earth; but its mean density is only a little more than half that of Jupiter, while that of Jupiter is approximately one-fourth of the earth's. This shows a wider dispersion of its matter, and therefore a proportionately larger electrisphere in relation to its mass. Then, viewed as a system, it has three thin, flat rings, the outer of which has a diameter of 173,000

miles and a width of 12,000 miles; the next within is 2,000 miles nearer the planet than the inner edge of the first, and is 17,000 miles wide; and the one nearest the planet is semi-transparent and has a width of 10,000 miles. It is now believed by all astronomers that these rings consist of swarms of separate particles closely aggregated, or, in other words, that they are meteoric rings. Here is further evidence of enormous exposure, and therefore of vast electrical charges. To all this must be added the eight satellites of Saturn, beginning with Mimas, which coasts around the rings at a distance of 34,000 miles from the outer, to Iapetus, which moves around the whole system at a distance of 2,225,000 miles. The phases of these bodies show that they behave to the planet as the moon to the earth; from which we may infer that their respective electrispheres are no larger than their material volumes. Still, each has its influence in the system. No one can properly consider all these facts without reaching the conclusion that the electrification of the Saturn system is proportionally greater than that of Jupiter and his family.

Uranus and Neptune are comparable to Jupiter and to Saturn in many of the particulars pointed out. They have enormous atmospheres. They are surrounded by vapor-

ous belts, which prevent a view of their surfaces. On account of its great distance from the sun and from terrestrial observers, Neptune has given up fewer of its secrets to astronomers than has Uranus, and much must be left to inference from the small data touching this remotest body of the Solar System now known. But there are ascertained facts about Uranus which tend to prove that it conforms to the rule as to proportional electrification. Its albedo is 0.64, which is two per cent. higher even than that of Jupiter, and twelve per cent. above that of Saturn. This suggests internal heat, self-emitted light, and a state of wide dispersion of the matter of its mass. Its mean density is only twenty-two per cent. of the density of water, which is two per cent. less than that of Jupiter. Besides, it has four moons which average about seven hundred miles in diameter and which cluster closer about the planet than do those of Jupiter and Saturn. It conforms to the law known as "Bode's Law" regarding the distance of planets from the sun. But the bearing of this must be made apparent hereafter.

Neptune does not conform even approximately to Bode's Law; but, since it has a wider orbit than Uranus, its place in the system harmonizes with the conception that it conforms

to the rule as to proportional electrification. The planet's position, being 2,800,000,000 miles from the sun (which is 800,000,000 miles nearer than it would be if it conformed with Bode's Law), is such as it might be if influenced by some extraordinary centripetal force emanating from the region beyond the Solar Domain, and continually urging it toward the center of the Solar System. Its satellite, which is estimated to be about the size of the moon, moves backward in its orbit; that is, from east to west—which is exceptional. These facts are in harmony with the supposition that Neptune is at the outpost of the Solar Domain.

VI.

The Real and the Non-real in Physics.

Of the many non-entitative things in physics which occupy the attention of philosophers, a few that are the less manifestly such are, for lack of discrimination, the occasions of inadequate conceptions and of misconceptions. Warmth, heat, light, weight, energy, attraction, force, and gravity are examples. Especially are heat and light constantly spoken of as if they were entitative. In the present chapter it is the writer's aim to put his readers on their guard against errors of the sort intimated, and to insist upon a just discrimination.

Until the beginning of the nineteenth century heat was believed to be a material substance, somewhat resembling the atmospheric gases, and capable of pervading other substances, as electricity and the ether pervade all matter. The general name *caloric* was given this supposed substance; and the notion survives in the word *calory* and in the voluminous accounts of *what heat does.* The slow evolution of the truth as to what heat is, if its story were fully written, would form one of the most

interesting chapters in the history of modern science.

The French physicist, Nicholas Leonard Sadi-Carnot, was the first intelligent doubter to repudiate the false hypothesis. What he thought and wrote on the subject, about the year 1724, remained unpublished till after his death, which occurred in 1732. Still later his brother incorporated it in his memoirs, a circumstance through which it escaped the attention of most leading scholars of the time. Yet, it may be justly regarded as the genesis of what are known to modern physicists as "The First Law of Thermodynamics," "The Mechanical Equivalent of Heat," and "The Doctrine of the Conservation of Energy." He held that heat is "rather motion that has changed its form." He wrote: "Wherever there is destruction of motive power there is at the same time production of heat in quantities precisely proportional to the quantity of motive power destroyed." And again: "Conversely, wherever there is destruction of heat there is production of motive power."

The next excellent doubter was Benjamin Thompson, an American. He was born in Massachusetts in 1753, sided with the British in the Revolutionary struggle, passed through a long series of public services in England and

in Germany, received from the pope the title of Count Rumford, by which he is best known, took as his second wife the widow of the French physicist Lavoisier, and died in her villa in Auteuil in 1814. While engaged in the making of cannon in the arsenal in Munich, he became interested in the production of heat by the process of boring the big guns. After various experiments which he conducted with intelligent attention and scientific accuracy, he concluded that the heat generated by the operation of boring is proportional to the time employed in the operation and not to the amount of metal cut away. The guns were heated, the tools were heated, the water in casings about them was heated; and he perceived a relation between the mechanical operation and the production of the heat induced. He concluded that this "something" which can thus be produced in unlimited quantities can not be a material substance. Unwittingly he was reviving and confirming Carnot's hypothesis, but after a lapse of three-quarters of a century.

Shortly thereafter Sir Humphrey Davy, the English chemist, confirmed the experiments of Rumford by rubbing pieces of ice together in a room whose temperature was below the melting-point, producing heat by friction sufficient to melt the ice. Of course, the experiment of

producing heat by friction had been known to the race ever since the first campfire was started by rubbing two sticks together till they burned; but Davy's experiment was sufficiently unique to give a new impetus to the old conception. Again, of course, the primitive campfire makers must have known and recognized, in a vague way, that the harder and faster they rubbed their dry sticks together the sooner the fire would start; but, not being philosophers, they did not consciously set before themselves the idea of the mechanical equivalent of heat. Nor did Davy exactly formulate the idea, though he was a philosopher.

Near the middle of the nineteenth century, James Prescott Joule, an English physicist, undertook by scientific experiments to discover the exact relation between heat and mechanical operations. He established a paddle-wheel in a vessel filled with water, and arranged to operate the wheel by means of a clock-weight. He dealt with known quantities; he noted the temperature of the water to be stirred, and of the atmosphere of the room in which his experiment was conducted; he took account of the loss of power by friction in the apparatus; and he discovered that there is a very exact and invariable proportionality between the mechanical energy expended and the amount of heat

produced. Estimating the work done by the weight in *ergs,* a very small arbitrary unit, he found that forty-two million ergs of work must be done to produce one *calorie* of heat; and, conversely, that when one calorie of heat disappears, some other form of energy equivalent to forty-two million ergs of work will invariably appear. Here is Carnot's idea revived and confirmed.

Rudolph Julius Emanuel Clausius, a native of Prussia and a celebrated professor in the University of Bonn, was Joule's German contemporary physicist; and William Thomson, the first Lord Kelvin, a native of Belfast and professor of natural philosophy in the University of Glasgow, was Joule's Irish contemporary physicist. These great thinkers devoted much attention to the development of the laws of Thermodynamics, and they established the idea that no heated matter, unaided by external sources of heat, can convey heat to other matter unless it be of a lower degree of temperature than its own. A body of higher temperature gives up heat to another body of lower temperature in contact with it, and this process continues till equilibrium of temperature is attained; but whatever quantity of heat a mass of matter may contain, and whatever may be the capacity of any adjacent mass for receiving heat, the

former will never raise the temperature of the latter above its own.

The conclusion reached from all this experimenting and thinking is, that "heat is a form of energy" or "a mode of molecular motion," and that it is generated or produced by any other "form of energy" capable of setting the molecules of matter in motion. Waves, pulses, or commotions of the ether of space, started by the sun or otherwise, provided they are of dimensions suited to this effect, are believed to be the indispensable cause of it. That is to say, all other causes operate through, and depend upon, these indispensable ethereal pulses.

Now, it has been shown that the ether does not act immediately upon matter, but mediately through the electric integument of atoms and of molecules. This being true, though ether waves of adequate dimensions be the indispensable cause, electrons constitute the indispensable condition of molecular motion. Of course, some sort of material molecule is indispensable. Then, the ether, electricity, and molecular matter are the entitative things required for the production of heat; and all else —waves, pulses, motion, energy, and heat— are non-entitative. Their names stand for conditions of entitative things, and not for substances; and it is of prime importance to keep

in mind that the effective agents which produce these conditions—the things which actually do all that is done in heat phenomena—are entitative and actual things.

But some one may say that heat affects our senses; that we feel it and recognize it as heat, not as ethereal billows, nor as electric tremors, nor as molecular motion. The truth of the answer will be perfectly obvious to any thoughtful mind. Ether pulses of heat-producing dimensions and frequency having set a mass of molecules in motion by agitating their electrons, their motion in turn is communicated to the electrons in the mass of our organs of sense. Then, mediately through these electric charges, and possibly through the ether, the mind takes cognizance of the commotion. If the agitation falls short of distress, we call it warmth; if it becomes in any measure distressing, we call it heat; if the pulses are of sufficient frequency to engage our optic nerves, the commotion reaches the seat of consciousness through the eyes, and we call it light. But these psychological effects are conditioned by the mechanical and material structure of our sense-organs, which are limited in their capacity for taking account of all that happens in the immaterial essences about us. All these commotions are homogeneous, though they vary in intensity and

otherwise; and they are all produced by actual essences as their prime causes. In brief, mere conditions are never prime causes in physics or elsewhere.

The obvious facts are, that the physical phenomena in question, if so defined as to connote their psychological effects, never occur where there is no sense-organ to perceive them; and that, viewed merely as transactions between the ether, electricity, and matter, they run through a long gamut in which only a few notes at wide intervals apart can be perceived by sentient beings. So vast are the intervals that widely differing organs are required to convey impressions of them to our minds; but there are reliable ways of ascertaining and recording the notes in this gamut, if one may so speak, which can not be caught by any of our senses. It is the province of the physicist to discover every note in the entire scale by any means available; and the sense-organs of human beings and of other beings are the most useful, though not in all instances the most delicate and accurate, of his apparatus. But, particularly, it is his care not to be misled by related things when investigating natural phenomena.

Precisely here lie the chief hindrances in the path of the natural philosopher. About every subtile interaction between the thingy agents

of nature cluster a multitude of non-entitative things which engross the investigator's senses and hold his attention. They appear to the senses to be the real agents in the transaction he is studying, whereas they may be merely bystanders. An instructive illustration of this may be seen in Joule's experiment already mentioned, and in the scientific dogmas it is supposed to support.

The main fact discovered by Joule was, to employ the current phrasing, "that for every unit of mechanical energy which disappears as the weight descends, a definite and constant quantity of heat appears in the stirred water." The inference is that "since work disappears as heat appears, and vice versa, heat is a form of energy." This case is usually given also as a special instance and illustration of the Law of the Conservation of Energy, which is, "That the sum total of the energy in any isolated system remains constant." Such expressions as "energy that has been converted into heat or some other form of energy," are current.

When these phrases are stripped of their inadequate conceptions and wholly erroneous conceptions, a complete revision of statement appears to become necessary. The *energy*—defined to be *power of doing work*—that moved the descending weight, was that of gravity,

whatever may have been the means by which the weight attained its "position of potential energy." Gravity acted on it while it was being wound up, while it waited before beginning to descend, while descending, and while at rest after the descent, constantly with the same "power of doing work." The "mechanical energy" of the phrasing above, which was expended in the winding up, opposed for a moment the energy of gravity, and was opposed by it; and these two equal forces "disappeared." Had Joule's device been "a closed system," in the sense of the doctrine of the "Conservation of Energy," its operation would have ceased with the winding, "by an isolated system being meant a system which can neither give up energy to its environment nor absorb energy from it," according to one of the highest authorities on the doctrine. But the infinite force of gravity, acting from without, caused the weight to descend. Obviously, therefore, neither "the work done in lifting the weight," nor the "power for doing" this work, nor the identical push of gravitational force which opposed the lifting, was "converted" into heat. The push which caused the weight to descend was subsequent to, and independent of, "the power to do work," and its exercise, by which the weight was lifted.

Turning now to another part of the experiment, the moving of the water—the work of the paddle-wheel—the mechanical result of the continual force of gravity, had this energy been expended in lifting the water, or in translating it from one point to another without stirring it, the heat would not have appeared. In all the voluminous discussions of this celebrated experiment during more than a half century, the indispensable condition of producing the heat has been overlooked or ignored. This is the more surprising in view of the fact that Joule, Helmholtz, Clausius, and Kelvin, who evolved the doctrine of the Conservation of Energy, were famously astute students of electricity and magnetism. The capital point is, that every molecule of water is a magnet, and that the stirring of the water disturbed the polary positions of these tiny magnets and thus called into resistance the "power to do work" which rotates the needle in a surveyor's compass. This energy, in opposing the disturbance, co-operated with the so-called "mechanical energy" in producing the etheric, electric, and molecular commotion detected by the thermometer and recognized by our senses as heat. But here, again, is energy from without the system —energy absorbed from the environment of the system—apart from which the heat would

not have appeared. Here, again, is incontestable proof that Joule's apparatus was not "a closed system" in the sense of the celebrated doctrine.

To define heat as "a form of energy" is merely to construct a phrase without making any progress in philosophy. To say that "heat is a mode of molecular motion" is inadequate, because this definition does not connote the thingy things which co-operate to produce it. To think and talk of heat as if it were the product of some of these things, ignoring the others, is misleading. To philosophize about "the mechanical equivalent of heat" without a thought of how far the "mechanical energy" of a system may act upon the subtile essences of Nature, or of how far their reaction may extend, is to fall short of the prime object of philosophy. To speak of any operative device which human skill can construct as "an isolated system," is to set forth an idea which has no foundation in fact. Not even is the Solar System isolated; nor, no more can isolation be predicated of it than of the planetary system of Saturn. To say that even the universe is "a system which receives no energy from without nor gives up energy from within," would be to assert without a sufficient induction of facts warranting the assertion. Yet, the so-called "First Law of Thermodynamics" rests on the assumption that

an isolated system, in the sense set forth, can and does exist.

What is here insisted on is that the thinking of the physicist is incomplete until he has traced out the connection between the non-entitative things he considers and the entitative things which cause them. For instance, philosophic inquiry as to gravity remains incomplete, for the reason that physicists do not yet understand what is the substantial agent of this force. Newton's inquiries and conclusions relate to *how* bodies attract one another, but not to *why* they do so. More recent inquiries, especially as to electrical phenomena, have led to the belief that electricity may be concerned with gravity, as an agent causing it; but no one who is competent to form an opinion on the subject supposes it to be the sole agent. One of the many serious attempts by physicists to explain why material objects approach one another, and seem to attract one another, is an attempt to make it clear that they are pushed into contact. Since the hypothesis was deemed worthy of space in the Proceedings of the Royal Philosophical Society, it may be given briefly here.

Professor Osborne Reynolds, of Owens College, Manchester, supposes all space to be occupied by a granular medium of exceedingly high density, the granules of which are normally

piled together like a mass of cannon-balls. These spherical particles of almost infinite diminutiveness are the substantial environs of matter. Matter, according to the theory, is vacuity within regions of abnormal pilings, wherein the granules are less numerous and the medium is less dense. The granules surrounding the less dense spaces, which we call matter, tend to push the abnormally piled granules into normal density, and this *push* is gravity. The push is accounted for by supposing the granules to be under enormous pressure. The deficiency of grains is described as a "singular surface of misfit." Briefly, matter is the quintessence of nonentity! Gravity is the tendency of primordial atoms to butt into nonentity!

If we inquire for the cause of the "enormous pressure," it will not be sufficient for the Professor to answer, "No matter!" Nor would we be enlightened should he answer, "Nothing!" His unaccounted-for "enormous pressure" throughout the universal medium leaves us a problem which differs in no important respect from that which he attempts to solve. About and beyond "vacuity" there is a *push* of granules; back of the push there is *pressure* which accounts for the push; but what is the cause of the pressure?

The hypothesis has the merit of pointing to a substantial "something" to be the cause of the condition explained; but the *modus operandi* of that "something" merely makes a game of "hide and seek" in which the cryptic phenomenon reappears in a remoter region of mystery. The hypothesis may, therefore, be dismissed respectfully as a clever but inadequate work of imagination. Respectfully, because every serious and intelligent effort to discover the absolute reality to which gravity is due, is worthy of thoughtful consideration. Besides, its implication and claim, that there is no attractive force inherent in masses of matter themselves, is in accord with the doctrine of the inertia of matter, and is fundamentally right and tenable. Unquestionably, whether gravity is the result of a *vis a fronte* or a *vis a tergo,* whether it is due to *attraction* or to *push,* an entitative agent is back of the action.

Of course, *weight* is a result of the *pull* or the *push* of gravity; and again, of course, we shall not understand what is the prime cause of weight till gravity is traced to its cause. But we know that weight has a definite relation to the atomic and molecular structure of matter. We know also that magnetism is an action of gravity through the wider separations between masses of matter, and that *cohesion* is

an action of gravity through the smaller separations of material masses. Further, we know that the etheric, electric, and molecular commotion recognized as *heat,* dissipates the forces of both magnetism and cohesion, with the result that, under heat, the one seems to disappear and the other relaxes in proportion to the intensity of the commotion. Here is ground for starting an inquiry whether some form of etheric, electric, and molecular agitation may, or may not, be the condition indispensable to gravity, and whether any of these is the absolute reality which is the cause of it. Later this inquiry will be pursued.

The present purpose being to promote just discriminations between actual realities and conditions of real things, and also between these and consciousness of them, *sound* may serve as another illustration. Whether noise, speech, or music, all sounds have a necessary relation to molecular, electric, and etheric commotion, and to consciousness. But sound is not a thingy thing. It involves conditions of entitative things and the perception of these conditions. In this sense it is comparable to light and to heat, as has been predicated above.

Acoustics is not merely "a study of waves in air." The scope of the science includes the nature and phenomena, the causes and effects,

of those vibrations of elastic substances of all kinds which affect the sensorium through the organs of hearing. Sound vibrations traverse the purest glass at a rate approximately twenty thousand feet per second; they traverse iron, steel, and aluminum at rates something above sixteen thousand feet per second; they advance through copper, brass, and along oak-fiber at rates approximating twelve thousand feet per second; they lag in water and alcohol at rates somewhat above four thousand feet per second; and they loiter in illuminating gas, air, and oxygen at rates not far from one thousand feet per second. The investigation of the progress of sound-waves in the different simple elements has not been accurately determined in every case; but here is enough to suggest accelerations, or more likely retardations, as uniform and as remarkable as the Periodic Law of atoms and as Bode's Law of planetary distribution. At least enough is known to warrant the conclusion that the progress of sound-vibrations in any material element is conditioned by the atomic and molecular structure of the given element. Besides, it is well known that the commotion which produces heat, retards sound-waves; for instance, about two feet per second for every degree in water.

Facilitated by surcharges of electricity and

magnetism in a telephone system, sound vibrations advance at a rate comparable to that of light. Produced by the vocal cords, they traverse the air to the thin diaphragm of steel in the transmitter, where the more intense magnetic field is encountered; traversing this magnetic field almost instantaneously, they are communicated to the air that is in contact with the magnetized steel diaphragm in the receiver at the other end of the line, and by the air to the drum of the listener's ear. Thence they advance through the nerves of the organ of hearing to the seat of consciousness. Through all these changes of conductors, every characteristic of the speaker's voice is preserved and faithfully transmitted, a most amazing fact, whether considered as a physical or a psychical phenomenon. That every pitch, tone, quaver, and quality is carried simultaneously along hundreds of miles of wire and through conductors consisting of gases, metals, and animal tissues; that they are conveyed across the line between matter and mind; and that the mind is capable of perceiving, comparing, and retaining all these complicate effects, are the capital elements of this wonderful fact.

If the telephone demonstrates that electricity and the ether are indispensable in the transmission of acoustic vibrations, the phonographic

record makes it equally certain that normally formed vulcanite, for instance, is capable of holding indefinitely and of reproducing the effect of such vibrations. Here a steel needle, so connected with a thin diaphragm as to receive the vibrations as in a telephone receiver, glides on its point over the smooth surface of the vulcanite, recording impressions of the vibrations. When the process is so repeated as to cause the needle to retrace its path, the sonorous vibrations are communicated to the air surrounding the diaphragm, and the sounds which affected the record are reproduced. A curious feature of the experiment is, that sounds made by cords and strings of all sorts of musical instruments, by whistles, pipes, and horns, by reeds, tuning-forks, and bells; and by concussions, frictions, or what not that makes any noise, are reproduced by a diaphragm of mica; and this shows that the fibers, metals, and devices with which we have learned to associate certain tones—as those of a fife, or violin, or drum, or bell, or piano, or the human voice—are not indispensable to the production of the sounds we associate with them severally.

It seems needless to say that all these facts point to one or more subtile agents, present in all substances, upon which the propagation of sonorous waves depends. It ought to be need-

less to add that the ether and electricity are obviously these agents. But if a doubt still lingers in the mind of any reader, let him thoughtfully consider whether sonoriferous waves would leave their trace on a photographic film if they also were not "etheric billows," as luminiferous waves are sometimes called.

There are many other non-entitative things that receive large attention in physics, the relations of which to entitative things need elucidation for the benefit of readers who are not specialists; but those only which come within the scope of this treatise can be mentioned; and gravity, magnetism, inertia, and a few others, must wait for treatment in future pages. However, a single additional thought must be given here.

Certain physicists have become convinced that atoms, the units in the ultimate division of matter, can be broken up into minute electric corpuscles, which are conceived of as *immaterial* substances. Again, certain philosophers promulgate the hypothesis that the minute corpuscles so derived are nothing else than "twists," or "knots," or "vortices" in the ether of space. Questions as to whether they were formed, and are capable of being straightened out; as to whether the formation was the result of inherent potentiality in the ether; and as to

whether they are eternal conditions, are being discussed by thinkers of all degrees of preparedness for discussions of the kind. The trend of modern science and philosophy is towards the conclusion that the ether is the only absolute Reality in the physical Universe. In the present study the evidences of higher and more potential Realities—of Vital and of Spiritual Realities—are laid before the reader.

VII.

Magnets and Magnetism.

Magnetite, or magnetic oxide of iron, got its name from Magnesia, a district of Thessaly, where it was discovered. Thales, who was at the zenith of his abilities about the close of the seventh century before Christ, mentioned the lodestone and its property of attracting iron. "Lodestone" is a later name for magnetite, however; for this must have originated after its polarity was discovered and after it became useful as a "lodesman" or a guide. Nothing reliable is known as to who discovered these remarkable properties.

The Chinese claim to have had very early knowledge of magnetite, and to have used it as a "south-showing" device since the time of the emperor Hoang-Tai, B. C. 2400; but competent Orientalists hesitate to accept as authoritative any Chinese records of matters more remote than eight hundred to one thousand years before our era. It is conceded that magnetite exists in iron deposits in Shensi, and that these deposits have been worked extensively by the Chinese since about 220 B. C. Here they had

the opportunity to discover its properties, and there is no ground for disputing that they did so. It is claimed by them, in *Poei-wen-yun-fou,* a Chinese encyclopedia, that during the Tsin dynasty, between 265 and 419 A. D., "there were south-showing ships," meaning that compasses constructed with the lodestone were in use. Near the end of the eleventh century a full description of the mariner's compass is found in a Chinese work entitled *Mung-Khi-pi-than;* and, it should be admitted provisionally, this is a little earlier than the appearance of the compass on the ships of the Mediterranean, so far as our knowledge goes.

It is an interesting problem for the curious, but it would lead too far afield into the history of the relations between the Chinese and the Seljuk Turks, who became dominant on the Asiatic side of the Mediterranean near the beginning of the Crusades; and it would require too much space for accounts of such peregrinations as those of Benjamin of Tudela, Marco Polo, and the emissaries of Kublai-Khan, who in that period acquainted Europeans with the Far East, and for the military operations of Genghis Khan, to deal adequately with the question of priority. But it is certain that the first treatise on the compass in European literature was written by Peter of Maharn, who,

on account of his participation in the Crusades, is better known as Peter Peregrinus. It is also a noteworthy coincidence that Genoese Crusaders were leading mariners of the period, and that a knowledge of everything pertaining to the navigation of the seas came naturally to Columbus by inheritance.

Peter of Maharn was called by Roger Bacon "one of but two mathematicians" of his time. His treatise was written on the 12th of August, 1269, in the form of an epistle to his noble friend, Syger de Foucaucourt. It is not too much to assume that he wrote it to convey a knowledge of what was not generally known. The instrument he describes has been characterized as being substantially "the azimuth compass of the present time." It must suffice here to enumerate the several facts about magnets and magnetism with which this scholar and writer had become acquainted.

1. He knew the lodestone as the source and means of the magnetization of steel needles used then in compasses.

2. That it attracts iron and, when suspended freely, arranges the two points thereof which most strongly attract steel so as to point to the north pole and to the south pole of the earth.

3. That the poles of a steel magnet, when suspended freely in the vicinity of a piece of

lodestone, arrange its axis parallel to that of the stone, but reverse themselves, so that the north pole of the one is attracted by the south pole of the other. He does not mention repulsion by like poles; but, from what he discloses, it is a fair inference that he was acquainted with this also.

4. That when a magnet is broken in two, each piece exhibits all the properties of the magnetized bar before being broken, the fact from which more recent philosophers have reached the conclusion that magnetism is a condition of the molecular structure of substances capable of exhibiting it.

5. That "from the poles of the world the poles of the magnet receive their virtue," which was contrary to a prevalent notion that the poles of magnets were drawn towards certain stars, or portions of the heavens, according as they were held when being rubbed with the lodestone.

6. He fully described the more primitive way of suspending the lodestone by floating it in a vessel upon water in a larger container, and a more recent way of suspending the steel on a pivot within a case. He directed that the azimuth bar be made of silver, and gave instructions for its use.

Thus it appears that the knowledge of magnets and an important mode of using them

were very far advanced at the time of the advent of the compass on European lands and seas. But many of its most interesting secrets were yet to be discovered, and some of them still wait for complete revelation.

For a long while it was supposed that the needle always points "true to the pole"; for, though slight variations were noted, especially by instrument makers, this was accounted for on the idea of imperfections of the instruments. On this account, it is quite possible instrument makers may have been slow to mention their observations of deviations from "the true north." However this may have been, Columbus is credited with the discovery of the new magnetic declination at sea, and observations of declinations on land immediately followed, as a matter of course. His discovery was made on his first voyage to the New World, and was the occasion of very great anxiety on the part of his sailors. This discovery opened the way for the scientific study of terrestrial magnetism.

In the year 1581, Robert Norman, an instrument maker, who had noted variations of the needle from the true north, wrote a treatise entitled *The Newe Attractive,* he having also discovered the dip of the needle in 1576. He had first communicated his observations to learned men; and then, upon their advice, had

constructed a dipping-needle with which he showed a "declining" of 71 degrees 50 minutes. He was anticipated in this discovery by George Hartman, of Nuremburg, vicar of St. Sabaldus, who was also a maker of sun-dials; but this fact did not come to light until a letter, written in 1544 to Count Albert of Prussia, was rescued from oblivion in the first half of the nineteenth century. But Norman's experiments were conducted with such carefulness, and his instruments were made with such skill and adaptability, as to entitle him to the chief credit of the discovery.

Norman reached two distinct conclusions as the result of his experiments and observations, which may be given in his own words, to show the high character of his thinking and his nice feeling with regard to the thinking of others:

1. "By the declining of the needle is also proved that the point respective is rather in the earth than in the heavens, as some have imagined; and the greatest reason why they so thought (as I judge) was because they never were acquainted with this declining in the needle, which doubtless if Martin Curtes had known, he would not have judged the attractive point to have been in the heavens, . . . but rather in the earth."

2. "And surely I am of opinion, that if this

virtue could by any means be made visible to the eye of man, it would be found in a spherical form, extending round the stone in great compass and the dead body of the stone in the middle thereof."

Here is the notion that magnetism is a something derived from the earth, through the lodestone, of course, and the additional notion that it takes the spheroidal form about the iron to which it is imparted, as well as about the lodestone. Considering that he knew nothing of electricity, this is an amazing anticipation.

In the year 1600, Dr. Gilbert published his great work, *De Magnete,* a treatise on magnetism and electricity. The chief merit of this investigator appears to have been in the wide scope of his experimentations, and in his effort to classify the knowledge gained on the subject up to the time of his writing. He so freely appropriated ideas from others as to leave it very doubtful whether or not he deserves very great credit as a discoverer. But he gave electricity its name and stimulated interest in the study of it; he believed it to be the agent of all magnetic effects; and he repeatedly insisted that "the earth is a great magnet." Sir Humphrey Davy gives him credit for the discovery that hammering iron and steel causes them to become magnetic, provided the rod that is hammered

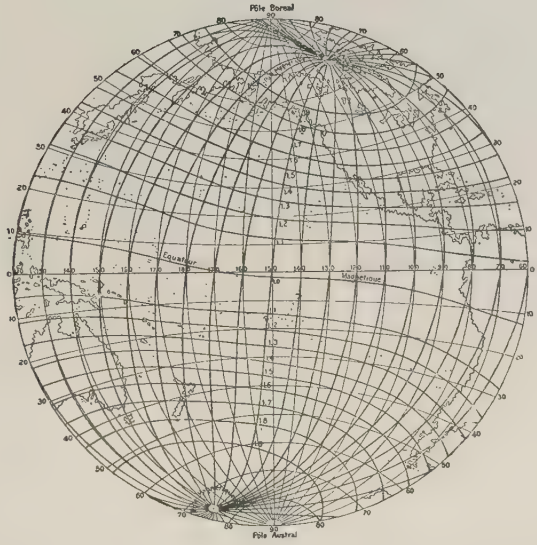
is held in a horizontal position and parallel to the earth's polar axis. His capital discovery seems to have been that the property observed by the Greeks on amber (electron) is to be found on many other substances; and his originality of thought is evident. He conceived that *electricity* (or the property of *electron*) is the essence of the "something which Norman supposed to surround all magnets." He thought of the earth as an immense lodestone, as being more potential in continental than in oceanic regions, and as being held in its place in the heavens and actuated in its motions by its magnetism; for, according to him, it would seem, electricity, magnetism, and gravity are one and the same thing.

From Gilbert's time forward both magnetism and electricity began to be investigated scientifically, and the number of investigators became very large. Geodetic surveys were undertaken by governments; navigators and land surveyors took note of variations of compass needles; men devoted to science made varied and extended experiments; and from all these sources a vast fund of information was gathered touching the magnetism of the earth. Coincidently, by sundry experiments in the field of electrical phenomena, an equally valuable store of knowledge was gained as to the relation

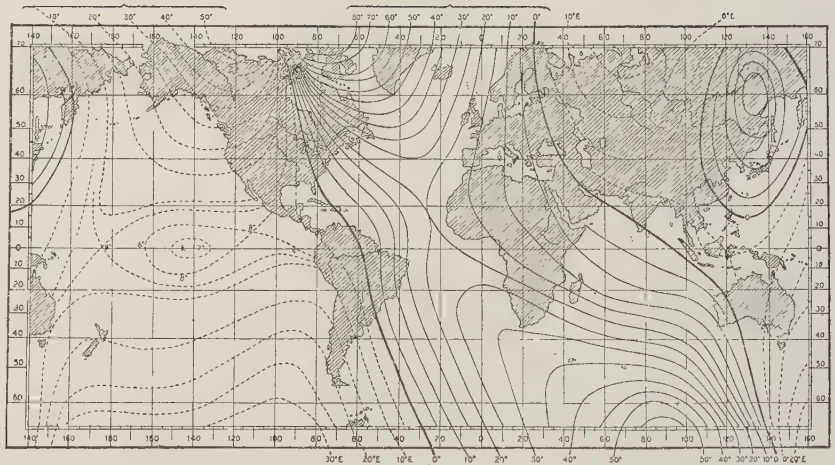
of electricity to magnetism. Also various substances were classified with reference to the influence of magnetism upon them. Of all that has been learned, only those facts which bear directly upon the discussion in hand can be enumerated here.

Contrary to all early suppositions, the magnetic poles of the earth were found not to coincide with its poles of rotation, the north magnetic pole being about latitude 70 degrees 5 minutes 17 seconds north and longitude 98.5 degrees west of Greenwich, and the south magnetic pole being about latitude 74 degrees south, and longitude 148 degrees east. A meridional belt or narrow strip around the globe, which traverses the continents and passes over the magnetic poles, is described as *agonic,* because there is no magnetic declination within this strip. It is indicated by a heavy dark line on isogonic charts. Several facts in regard to it, which the writer considers of special importance in the present study, may be enumerated.

1. It is approximately a mid-continental belt. Tracing it from the south magnetic pole in the eastern hemisphere, it runs not quite due north to Australia, and crosses the western section of that continent; thence it veers westward to the southern extremity of India, and traverses the Arabian Sea and the Persian Gulf; thence it



MAGNETIC & GEOGRAPHIC POLES OF THE EARTH, SHOWING THE MAGNETIC MERIDIANS FOR 1836 DRAWN BY CAP. DUPERRY. REPRINTED BY PERMISSION FROM PRINCIPAL FACTS OF THE EARTH'S MAGNETISM. U.S. SURVEY



—LINES OF EQUAL MAGNETIC DECLINATION FOR 1905 (BRITISH ADMIRALTY).

[Full lines indicate west magnetic declination and broken lines east magnetic declination.]

HEAVIEST LINES THE AGONIC. REPRINTED BY PERMISSION FROM PRINCIPLE FACTS OF THE EARTH'S MAGNETISM. U.S. SURVEY

turns more to the due northward across the Black Sea and through Russia to the north magnetic pole, all of Africa lying to the west of it. In the western hemisphere it crosses the western portion of the Hudson Bay, and traverses Canada to the Great Lakes; thence it passes through the United States to the Caribbean Sea near the point of Florida; thence it runs through the West Indies to the extreme northern boundary of South America; and thence it lies across Brazil, keeping nearer to the Atlantic than to the Pacific Ocean.

2. Its course is evidently influenced by the width of the two great oceans between which it runs. On land it is everywhere nearer to the Atlantic than to the Pacific. Its course everywhere appears to be along the mean between two repellant agents active in the two oceans, that in the Pacific being the more influential.

3. The following statement is made in a report of the United States on magnetic declinations and isogonic lines in 1902: "If the longitudes of the intersections (at the equator) were determined from time to time and represented graphically, the ordinate being the longitude and the abscissa the corresponding year, it would be seen that for nearly three hundred years there has been a progressive and almost

uniform motion of these two agonic lines to the westward, the western agonic at an average annual rate of nearly 14 minutes in longitude and the eastern agonic at an average annual rate of about 8 minutes in longitude. Were the western agonic to make a complete revolution of the earth at the rate given, it would take it nearly one thousand six hundred years, whereas the eastern agonic requires about two thousand six hundred years." A careful study of a chart showing isogonic lines—that is, lines of equal declination—will convince the observer that the farther they lie from land and the warmer the regions through which they run, the greater is their longitudinal extension.

Magnetic meridians—that is, lines which one would mark out should he follow the leading of the magnetic needle from south to north in any portion of the earth—are never invariable in direction. The larger and general directions in which the needle leads are altered by purely local causes, and these are more or less intense in different localities over the face of the earth.

Professor A. W. Rucker, who with Professor Thorpe conducted a recent Magnetic Survey for the British Government, has published detailed and very interesting proofs that deep-hidden mineral deposits in large masses attract

the north pole of the needle through regions of great extent, and he thus accounts for some of the local disturbances. Contrary to the notion that has occasionally been revived since Dr. Gilbert suggested it, the earth is not one great uniformly magnetized mass. It is rather an aggregation of magnets. Being freely suspended, it is moving in a magnetic field, and the different portions of it are being variously influenced by magnetic currents into which they fall, or through which they pass. The magnetic condition of the earth as a whole is similarly affected.

There are periodic alterations, due to the several periodic motions of the earth and of the other planets of the Solar System. Daily, as the earth turns on its axis, the needle varies in mean latitudes of the northern hemisphere eastwardly and westwardly as if the north-seeking pole were avoiding the sun's rays, or as if repelled by them. Samuel Hunter Christie, a member of the Royal Society and colaborator of Dr. Peter Barlow, after extended experiments in 1826, announced his conclusion "that during the vibrations of a magnetized needle exposed to the solar rays, these rays have an influence on the needle independent of the effect of heat, which tends to bring the needle to a state of rest." Of course, in the southern

hemisphere the daily movements are similar, but in exactly the opposite direction.

Annually, as the earth moves around the sun, when the sun is north of the equator there is a slight eastward displacement of the declination of the needle, and a westward displacement when the sun is south of the equator. The dip of the needle is greater during our winter, and less in summer. It is a capital fact that in every respect the magnetic intensity in all parts of the earth is greatest in winter, being proportional to the planet's proximity to the sun. From October to January the north pole of the earth appears to be continually retarded in the perihelion approach, being repelled as is the north pole of the needle in the diurnal variations. After perihelion the apparent repulsion gradually diminishes till aphelion in midsummer, and the poles of the earth coincidently seem to move in the opposite direction in relation to the sun.

The moon, by its successive transits across the meridian of any point of observation upon the earth, has a very perceptible influence in magnetic variations. The sun's period of rotation on its axis has similar influence, the period being twenty-six days. It has been conclusively shown that all the planets produce magnetic effects upon the earth periodically in their courses.

There are secular changes or variations in the direction of magnetic forces that are progressive and slow, but that are not yet known to be periodical. Some of them are approximately so, and several periods have been made out for both the declination and the dip of the magnetic needle, as well as for magnetic intensity. When it is remembered that magnetism is the bond that unites the worlds in each system, that holds each system of the universe in its relation to neighboring systems, and that maintains the integrity of the universe, it becomes perfectly obvious that magnetic variations must be infinite. Nor is it possible to account for the motions of any planet by supposing them to result wholly from the influence of a central body, as the sun in our system, nor from the combined influence of all the bodies in the system. No more is it possible to account for the variations of magnetic needles, horizontal or dipping, by reference merely to terrestrial and solar influences, except in the sense that whatever affects the earth's magnetism also affects in some measure the magnetism of every magnet on the earth.

The English astronomer, Richard Proctor, said: "We must make an approach towards mastering the relations between the sun's actions as a center of many forms of force, and

the phenomena of terrestrial magnetism, looking upon these phenomena as indicative of processes which affect the whole solar domain. When we remember that the appearance of intensely brilliant light-patches on the sun's orb has been found to be accompanied by an instantaneous thrill of the whole magnetic frame of the earth, presently followed by the appearance of auroral lights in both hemispheres, we recognize the action of solar influence which must be capable of largely affecting such bodies as comets." This is a large view of magnetism; but it is inadequate, as Proctor himself very well knew.

Sir John Herschel says of the Galaxy, or Milky Way, that its plane "is to sidereal what the ecliptic is to planetary astronomy, a plane of ultimate reference, the ground plan of the sidereal system." He was first to point out that this immense circle intersects the ecliptic at two opposite points near the solstices, making with it an angle of about 60 degrees. But this constant relation is unquestionably maintained by magnetism. Its relation to the plane of the orbit of the Solar System, one might say, is maintained by magnetism; and yet, this is a limited view. Those thrills "which affect the whole solar domain," with the regularity of sun-spot periods, may not originate in our cen-

tral orb, but may come from far afield in the starry expanse, affecting the sun and his attendant planets simultaneously.

The notion of approximately circular "closed orbits," or paths along which the planets run their course around the sun, returning periodically to their starting-places, is a mere fiction of astronomers which does not deceive them, though it fosters erroneous popular beliefs. Since the time of the Herschels and the Russian astronomer, Frederick Von Struve, it has been conceded by astronomers that the sun and all the planets of the Solar System are moving in the direction of the constellation Hercules with a velocity of about twelve miles per second. Thus the planets, while making their orbital journeys about the sun, advance toward their apparent goal about 400,000,000 miles in a year of terrestrial time. The earth, for instance, at the beginning of a new year is almost as far from the place in space where the old year was begun as the distance from the sun to the planet Jupiter. While moving along its orbit at the rate of 6,660 miles per hour, to which speed a thousand miles per hour must be added to get the pace at which the average inhabitant is speeding at the surface of the revolving globe, the earth is describing a helix at a great rate of speed, forty times greater

than that of a cannon-ball, in its advance towards the apparent destination of the whole system. We can not consistently say, with Hermann Ebert, of the University of Kiel, that "magnetism is a universal bond which unites world to world," without making the tacit admission that it is the bond between the Solar System and other systems of the universe, and that the entitative agents which produce it are concerned in all their various motions.

The facts about magnetism illustrate the statement that "astronomy is physics operating in a wider sphere." The physicists agree in thinking that magnetization consists in the arranging of all or most of the molecular magnets of a substance with their poles in the same direction. The French physicist, S. Poisson, held that molecules become magnets, and that there is no molecular movement in magnetization; but all now follow the German physicist, W. Weber, who supposed them to be always magnets and to be polarized in the process of magnetization; and molecular magnetism is now called "primitive." Faraday showed that all substances are subject to magnetic influence, but that different substances or elements behave differently under this influence. Iron, steel, nickel, and cobalt retain magnetism more or less permanently; and these substances, when mag-

netized and suspended freely between the poles of any strong magnet, arrange their polar axes parallel to the "lines of force" from pole to pole of the strong magnets. He, therefore, called these *"paramagnetic"* substances. Other substances arrange themselves lengthwise across the "lines of force" between the poles of a magnet, and these he called *"diamagnetic"* substances. Hans Christian Oersted, the Danish philosopher, discovered that a magnetic needle sets itself at right angles to an electrified wire or coil of wire through which a current of electricity is passing. Faraday discovered that the field within such a coil is magnetic.

Now, with these facts of physics in mind, let the reader suppose himself to be at some point of the equator, say by the Lake Victoria Nyanza, on either the 22d of September or the 20th of March, or at the time of the autumnal or of the vernal equinox. He may suppose himself to be equipped with a horizontal and a dipping-needle, an azimuth compass, a gnomon, a transit circle, a zenith telescope, and a suitable chronometer.

His dipping-needle will dip neither at its north nor at its south end, but will behave as his horizontal needles behave, pointing due north and south, with no display of intensity. All the needles will be parallel to the earth's

polar axis, and a line from the nadir projected through his zenith will pass through the sun at noon. The plane of the equator will coincide with the plane of the ecliptic. The line of the earth's axis will be at right angles to its radius vector, and produced to the vicinity of Polaris will show that the celestial pole is about 1¼ degrees away from the "pole-star" in the direction of Ursa Majoris. The problems suggested in these circumstances are problems of physics or of astronomy, or of both, as he may choose to regard them.

Why does the dipping-needle refuse to dip? Why are all the needles parallel to the earth's axis? Why is the earth's axis at right angles to its radius vector which lies in the plane of its equator? Is the earth paramagnetic or diamagnetic? Is it a permanent magnet or a temporary magnet? Do the "lines of force" which control its attitude run eastward and westward, or northward and southward? Or are there "lines of force" which intersect within it? Other problems suggest themselves, but these are sufficient for the purpose of their enumeration.

About the year 1819, Dr. Peter Barlow, of Norwich, England, undertook the experimental investigation of the phenomena of induced magnetism, with a view to the neutralization of the

influence of the iron in ships upon mariners' compasses. His first capital discovery was that such effects are not intensified by the mass of the iron or steel, the influence being due rather to the extent of their surfaces. His experiments were made with magnetized needles in the vicinity of both shell and solid globes of iron and of steel. This discovery led Mr. Charles Bonnycastle (who afterward became a professor of mathematics in Virginia University) to inquire experimentally into the behavior of magnetic needles in the vicinity of a sphere whose magnetism was induced by electric currents. This experiment confirmed Barlow's findings; and shortly afterwards M. Poisson, the French physicist, submitted Barlow's so-called "laws" to mathematical analysis, and he also confirmed them. With reference to all this, Barlow says in one of his communications to the Royal Society:

"It follows from these laws, that if an iron sphere, such as we have supposed in a transient state of magnetic induction, be made to act on a magnetic needle isolated from terrestrial magnetism, it will produce in the needle all the phenomena which Mr. Humboldt observed, and which M. Boit and Kraft reduced to determinate laws of action; . . . hence, then, it follows: (1) That the laws of terrestrial magnetism are

inconsistent with those which belong to a permanent magnetic body, and (2) that they are perfectly coincident with those which appertain to a body in a transient state of magnetic induction."

Then, when Oersted announced his discovery, that a magnetic needle takes up a position at right angles to an electrified wire, Barlow renewed his experiments, "to elicit in this case also the laws which govern the reciprocal action of the wire and the needle," and he reported his conclusion in the following proposition:

"That the force of each particle in the wire on each particle of the needle varies inversely as the square of the distance, and that the nature of the force is tangential; that is, such as would place a needle neutralized from the earth's magnetism always at right angles to the direction of the wire, and to the direction of the line joining the needle with the center of action of the wire."

Contemporaneously M. Ampere and M. Arago, collaborating with a wider scope of observations and with better equipment, were dealing with the same matter incidentally. They learned that to reverse the direction of the current through a coil of wire around a core of soft steel was to reverse the poles of the temporary magnet thus formed. This was the

occasion of Barlow's inquiry as to the direction of the currents he supposed to be flowing around the earth, and again he was strengthened in his former conclusions. Meanwhile Ampere was devising electro-magnetic needles, magnetic coils, magnet-spheres, and systems of electro-magnets, and was studying their reciprocal actions. Commenting on his results, Barlow wrote:

"The law of action of galvanic currents on each other was reduced to that of attraction; and, by assuming the magnetism of the needle to be due to an infinite number of galvanic currents parallel to each other and at right angles to the axis, the action of needles on each other, of these on galvanic currents, these currents on each other, and of the earth itself on each, were all reduced to one general principle, admitting of accurate and determinate calculation."

Not forgetting that the reader has been asked to take up his position, in fancy, in equatorial Africa, and that he is now supposed to be making his observations under the noonday sun on the shore of Victoria Nyanza, the influence of heat on magnetized substances will not be inappropriate. He should learn, or recall, what others have discovered on this point; and in this Barlow is the pioneer. That is, he was first to investigate the matter scientifically. It

had been stated by Sir Isaac Newton in "Optics" that red-hot iron has no magnetic property. The Jesuit Father Kircher had said that hot iron will attract and be attracted the same as when cold. M. Cavello had asserted that iron at the red heat has more power over a magnet than when cold, and less at the white heat; and William Scoresby, Esq., had reported to the Royal Society at Edinburgh that the red-hot iron has greater power, though he said nothing of the effect of white heat. To ascertain what was the occasion of these discrepant statements, and to learn the real truth of the matter, Barlow led his associates in a long series of experiments which brought to light several very remarkable effects. Briefly they are:

1. That at white heat all magnetic effects disappeared, whether cast or wrought iron was used, the test having been made with the magnetic needle in different positions near the heated iron bars which were employed in the experiments. The positions were from one to twelve inches away—usually at an angle of 80 degrees from the middle of the bars, north, or south, or east, or west, sometimes a few inches above and sometimes a few inches below—care being taken always to enable exact comparisons to be made as to the effect of

alterations of distance, altitude, and angles.

2. That at red heat all normal deflections were reversed in all the positions indicated. "For example," says the experimenter, "when the compass is above the center of the bar, the north end of the needle should be drawn towards the iron, but when the compass is below the center, the south end should approach the iron;" and these were reversed at the red heat.

3. That at the blood-red heat all normal deflections were very decidedly increased, as compared with observations made with cold bars of equal dimensions, tested in like positions.

4. That at red heat and also at blood-red heat, at all angles and distances of the tests, deflections below the bars were greater than above the bars.

5. That at red heat and also at blood-red heat, deflections at north 80 degrees east were greater than at north 80 degrees west, the distances and altitudes of the needle being the same.

Samuel Hunter Christie, in researches made at Barlow's suggestion, found: (1) That the intensity of the magnet increases with every degree of cold to the lowest temperature to which he exposed the magnets with which his tests were made. (2) That the decrement of

intensity was not constant for every temperature. Up to 80 degrees it was nearly constant. Above 80 degrees the decrement was more rapid. Beyond 100 degrees "a portion of the power of the magnet was destroyed"; and upon a change of temperature the magnetic intensity changed almost instantly. (3) The susceptibility to magnetic influence, or the permeability, to use a term employed by Maxwell long after, increased with temperature up to 100 degrees in his experiments. Mention has already been made of his finding that heat diminishes the intensity and tends to bring the needle to rest nearer the meridian.

The facts thus far recited in this chapter give a fair idea of the progress that had been made in the study of magnetism up to about 1830, if we add Sir Humphrey Davy's discovery that a few taps with a hammer on an iron rod, held in a vertical position, will magnetize it; that a single tap on the reverse end will demagnetize it; and that a few additional taps in the same position will remagnetize it, reversing the poles; for the end near the ground during the process will always be the north-seeking pole of the rod or bar thus magnetized. Perhaps what Davy regarded as his greatest discovery should be added just at this stage of the progress of the science; namely, Michael

Faraday! Some of Faraday's discoveries have already been mentioned, and others fall into a class by themselves.

In 1831 he made the discovery that led to the development of the dynamo, which is essentially a magnetic machine. Having conceived the notion of "lines of force" between the poles of a magnet, he arranged a copper disk—a diamagnetic substance—to be rotated between the poles of a horseshoe magnet, so that the radius (or its substance lying between center and circumference) would continually "cut the lines of force." He arranged a metallic brush to be in contact with the axle on which the disk revolved, another to be in contact with the periphery, and connected these by means of a metallic line, thus forming a circuit from center to periphery. It was found that the circuit became electrically charged. Thus it came to be known that electricity can be mechanically "induced" in the manner described, that magnetic fields can be set up in any part of a circuit and can be increased in intensity by forming coils and introducing soft steel into them, and that electric motors—already known in crude forms—can be actuated by currents thus "generated." Here was another great fact showing the connection between electricity and magnetism.

He discovered that there is a proportionality between the amount of electricity normal in any substance and the chemical activity of which it is capable. That is, there is a proportionality between the valency of a substance and its normal electrical charge. In electrolysis the decomposition is proportional to the amount of electricity passing through the electrolyte. The elements of the decomposed substances are always just sufficient to reunite without leaving anything over of either. This points to the fact that cohesion depends on the amount of electrical charge, as also chemical dissolution does; or that valency is but another name for a magnetic property, and for an electrical condition.

In 1845, Faraday noticed that a dense borosilicate of lead, when in a strong magnetic field, rotates the plane of polarization of light transmitted in the direction of the field. If the light-waves proceed in the same direction as the "lines of force," the rotation is positive —according to the "right-hand-screw rule"; and if they pass in the opposite direction, the rotation is negative. In a direction perpendicular to the field, the polarization is unaltered. It has since been ascertained that the phenomena are not peculiar to this or to any particular substances.

It is convenient to mention in this connection that, in 1876, Dr. W. C. Kerr discovered that when plane-polarized light is reflected by a magnetic pole, the plane of polarization is turned through an angle which depends on the intensity of magnetization. And, in 1890, H. E. J. G. du Bois announced that the rotation of the polarized ray is proportional to the intensity of the magnetism. All these facts, whatever else they may indicate, prove very clearly that there is a relation between ethereal agitations and magnetism. They tend to show that the ether is one of the agents to which magnetization is due.

In 1869, Professor George Gore, an English physicist, discovered that an iron wire cooling from a bright red heat suffers a momentary elongation at dull red, and then goes on contracting as before. In 1873, Peter Tait, Professor of Natural Philosophy in Edinburgh, noticed that the thermo-electric quality of iron suddenly alters in a remarkable way at red heat. The next year Professor William Barrett, a Jamaican by birth and for a time an assistant of Tyndall at the Royal Institute, discovered what is called the *recalescence* of iron and steel. When heated to a bright red and allowed to cool slowly, they suffer a sudden check in cooling at the red heat—or at the stage of

Gore's phenomenon—as if heat were generated in the substance. All these facts recall and confirm Barlow's observations of "the anomalous" behavior of a magnetized needle in the presence of heated bars of iron cooling from the bright red to the red heat.

About 1891, John Hopkinson, an English electrical engineer, found that wrought iron subjected to a weak magnetic force becomes highly susceptible to magnetization so long as the temperature is not above 775 degrees centigrade. Up to this degree heating increases the susceptibility; and at this degree of heat it is many times greater than in cold wrought iron. But at higher temperatures a sudden loss of magnetic susceptibility takes place; and at 786 degrees it practically vanishes. In brief, there is a critical temperature for magnetic susceptibility.

In 1897, Dr. D. K. Morris prosecuted a series of experiments along the same line as those of Hopkinson, and through a wider range; and he found that the increment of susceptibility is not constant up to the critical temperature. In three specimens with which he made tests the rise was rapid to 300 degrees centigrade. Between 400 degrees and 500 degrees it was constant. Thence to 750 the rise was again rapid, reaching a very high value. For these

specimens 770 degrees, 780 degrees, and 795 degrees were the several critical temperatures found. From these tests and those of Hopkinson, the inference is that impurities and different degrees of hardness affected the results, and will always do so. In fact, Isaac T. Osmond, an American, a graduate of Cornell, found that in hard steel there is a wider difference between magnetic and non-magnetic conditions at the critical temperature.

Since etheric agitation which causes heat causes also a state of strain tending to rend the molecules asunder, the facts just enumerated furnish an interesting transition from the subject of the influence of heat on magnetization to that of the influence of other forms of stress and strain.

A magnetized bar increases in magnetic force when pulled lengthwise. This was discovered as early as 1847 by V. R. Matteucci, who in April, 1906, won the world's admiration by remaining at his post as director of the Royal Observatory on Mount Vesuvius during the terrible eruption. In 1868, Pasquale Villari, another Italian scholar, found this effect to occur only when the magnetization is weak, and that it is reversed when the magnetization is sufficiently increased. In very strong magnetization the result of such strain is the loss

of magnetism. This effect was rediscovered by Lord Kelvin while investigating longitudinal stress by loading and unloading a wire under the influence of magnetic force.

Mr. Shelford Bidwell, in 1888, showed that an iron rod lengthens when it is magnetized, provided the magnetizing force does not exceed a certain limit, but shortens when the force exceeds that limit. This critical point of strain should be studied in connection with the strain of the critical temperature.

It has been shown by different experiments, by several investigators, that twisting reduces magnetism, and untwisting increases it, when a wire, rod, or bar is under the influence of a magnetizing force. Of course, twisting is a mode of pressure.

Professor A. J. Ewing, of Cambridge, England, who has studied all these and like instances and has written learnedly on magnetism, has noticed a certain persistence in magnetic states which he calls *hysteresis,* from the Greek word *hystereo,* to lag behind. It is perceivable throughout the whole range of magnetization. It is a reluctance to change from one state to another. This must be understood to have a definite relation to all so-called "critical points" of temperature and of magnetization, and also to the persistence of elec-

trical charges. The latter has been discussed in one of the foregoing chapters.

Under the strain of etheric pulses substances pass from temperatures too low to affect the optic sense, and thus to produce light, first to red, then to bright red, and then to "white heat" and to "blue light," at irregular intervals of temperature; but not for the reason that there is variableness in the increment of electro-etheric agitation. Different substances, being various in their capacity for electric charges, solidify or freeze at different temperatures. For the same reason they melt, boil, vaporize, and are dissociated at different temperatures. In the light of these facts the whole gamut of electro-ethereal effects upon the different elements may be studied, and the elements themselves may be classified, according to the different ways in which these electro-ethereal commotions are received, limited, and conditioned by the different substances.

VIII.

The Ether and Magnetism.

The foregoing chapters may be regarded as an induction of facts which form the basis for the conclusions hereinafter to be set forth. It may now be stated as a thesis, rather than as an hypothesis, that electricity and the ether of space are the entitative agents to which magnetism, cohesion, valency, and the attraction of gravitation are to be attributed. In truth, to establish this thesis is one of the aims of the present volume.

Since all truths harmonize, it is of the first importance to show that this proposition is never contradicted, but is in harmony with all the findings of scientists touching electricity, the ether, and matter, so far as these findings are explicable. This may be done in a step-by-step progress, elucidating magnetism, cohesion, valency, and gravitation, a task which will seem to many to be chimerical, if not downrightly presumptuous.

Magnetization, considered as a condition of iron or steel, for instance, is a mode of electrification. Take Sir Humphrey Davy's experi-

ment in which a rod is magnetized by holding it in a vertical position and tapping it on the upper end with a hammer. The tapping produces a vibration of the molecules favorable to a partial discharge of the rod's electricity to the earth. The upper end suffers more loss than the lower, the movement being towards the earth, and the lower end becomes positive as to the upper end. But the answer to any *why?* is always likely to be followed by another *why?* It may be asked, Why does not the iron lose all of its charge? Or, Why is the residual charge unequally distributed among the molecules of the metal after the jarring?

The reluctance of the iron molecules to give up their charge completely harmonizes with Ewing's hysteresis, and with the well-known fact that electricity clings tenaciously to matter, so that no particle of matter has ever been known to be completely denuded of this subtile essence. From their compactness, or from some molecular arrangement peculiar to them, paramagnetic substances have the capacity to hold their molecular charges within limited ranges of molecular strain. But, for example, when heat overcomes cohesion, the redistribution of the molecular charges will be facilitated up to a certain degree of separation; and then at wider degrees of separation the metal will

become incapable of holding the molecular charges in the manner peculiar to paramagnetic substances. This harmonizes with the findings of Tait, Hopkinson, Morris, Osmond, and others, as to critical points of temperature in magnetization.

Still, an explanation of what magnetization is falls short of an elucidation of what magnetism is. Granting that the difference between positive and negative poles may be due to a difference in electrification, as indicated by the experiment of the rod, it yet remains to account for the attraction and repulsion of magnets. This quality is due to the agency and action of the ether.

As has been intimated, magnetization is a state of extreme molecular loss of electrical charge; and an unequal distribution or arrangement of the residual molecular charges accounts for the phenomenon of polarity. A mass or a molecule in such condition as to have the motion of its charge or its electron impeded, resists and is resisted by the ether waves falling thereon, with the result that the direction of these waves is altered. Eddies and vortices in the ether around the mass are occasioned. Waves leaving the mass in various directions are turned back upon it by waves arriving from all directions. Waves meeting at the center of

the mass neutralize one another. The neutral center does not differ from the poles in the character of magnetization, its neutral behavior being due wholly to the meeting and reaction of the ether pulses.

Now, additional *whys* come trooping up. Why does the one pole of the freely suspended magnet swing round to the north, and why does the other pole seek the south? Why does the one dip towards the earth while the other rises towards the zenith? Why are paramagnetic substances attracted by the pole, and why are all substances influenced by the action of the etheric vortices so set up? Why do paramagnetic substances arrange themselves parallel to the direction of the waves between the poles of a horseshoe magnet, and why do diamagnetic substances arrange themselves otherwise? A score of other *whys* could be mentioned; but this group should be given attention before taking up the others.

1. The earth being a magnet, the directions taken by ether waves falling upon it are similar to those just described; and the waves directed northward and southward by this greater magnet co-operate with those directed by the smaller magnets. When ether pulses fall on the pole of the magnet having the greater electric charge, it moves toward the point at which the force

of these pulses is least felt. The earth being negative, and the north magnetic pole of the earth being especially so as compared with the equatorial region, there are fewer reacting waves from those directions. Hence, for the positive pole, the least resistance is found in the earthward and northward direction. But for the negative pole, the equatorial region and the region of the upper atmosphere, which are positive, offer the least resistance.

2. Paramagnetic substances, falling into the etheric vortices, are carried along in the direction of the least impeded waves more forcefully than diamagnetic substances for the reason that their molecules and atoms—or their primitive charges—oppose more resistance to the etheric pulses. In the neutral region of the magnet they behave much as other substances; but in the currents which set towards the poles of the magnet, they are carried to the poles as to a center of gravity. There being in diamagnetic substances but little fixedness of the molecular and atomic charges, they arrange themselves in neutral regions in the midst of the etheric commotion. Still, if they be moved to and fro within a magnetic field, they will reveal the influence suffered by resisting the movement, being held as if in a viscous fluid; and, as Faraday showed, they will take up positions

at different angles to "the lines of force," to use his phrase, according to their diverse structures.

Now, why soft steel becomes a temporary magnet within a coil of wire through which an electric current is passing becomes obvious. In any ordinary system of electric conduction the wires become channels and conductors of etheric pulses or waves. Etheric vortices, and therefore magnetic fields, are formed by coiling the conducting wires. The introduction of the soft steel—a paramagnetic substance—into such a coil increases the magnetic force. But why?

Soft steel is so tempered as to leave it rather rich in molecular electric charges. If made very hot and then plunged into water, it would part with very much of its electricity to the vaporizing fluid, and would become very hard. But if immersed in oil, or enveloped in dry dust, it would retain much more electricity. Its particles would then move over and about one another more freely, and it would be softer and would bend more easily. Then, in the vicinity of a strong etheric current—or chain of rapidly succeeding ether waves—much of this abundant charge is carried away, with the result that it affects the ether as any other partially discharged paramagnetic mass. While the current flows it is a magnet; but, allowing for

hysteresis, so soon as the current ceases, it appropriates from surrounding elements electricity to restore the loss, and it ceases to be a magnet.

Again, why an electric coil within which there is a magnetic field arranges its poles at right angles to a wire through which a current is passing, and why a magnetic needle does the same thing, will be readily understood in the light of the foregoing explanation. Just as objects on either side of the path of a cyclone are moved at right angles to the line of the cyclonic movement, and are drawn into the vortex, so are magnetized bodies rotated and held by the directed etheric cyclone in the wire. If a way can be made to test the matter, it will be found that even the molecules of the atmposphere in the vicinity of conducting wires are similarly rotated and polarized.

It follows, then, that three entitative things are indispensable to magnetic effects; matter, its primitive electric charges, and the ether of space. Then, the relation between the particles of the matter and the electronic charges—or the arrangement of the matter and the electricity—capable of producing etheric vortices, and the etheric commotion commonly described as pulses and waves, are the indispensable conditions in which these effects occur. All the

phenomena of magnetism are explicable by the actions of these agents, the conditions mentioned being present.

In studying the effects of the earth's magnetism upon the smaller magnets of our experiments, the fact must never be lost sight of that the agents which produce the magnetic condition of the earth and that of the smaller magnet, are acting upon both at the same time and in the same way, while the magnets are reacting upon each other. For instance, the smaller magnet, if completely freed from the influence of the earth's magnetism, would take up its position in space at such an angle to the axis of the dominating etheric waves as its individual structure would determine. But in the vicinity of the earth it arranges itself, or is arranged, under pressure of the earth-directed waves as well, which are out of all proportion more potential than those directed by its own electrification. The action of each upon the other is proportional to their individual atomic and electronic components, and to the square of the distance which separates them. Also their reciprocal action is conditioned by the direction given the etheric waves encountered, as already intimated above.

So, then, what Dr. Barlow described as "the anomalous" behavior of magnetic needles in the

vicinity of heated bars of iron—which is equal to saying under the influence of etheric billows —was not anomalous, but was entirely regular and ordinary. Also the several interesting phenomena observed by his associate, Professor Christie, in his study of the influence of light and heat from the sun upon magnetic needles, when considered as resulting from etheric action upon electrified matter, are not only explicable, but are even obvious. For instance, below the hot bar the needle was in the path of the waves to the cold and negatively charged earth, and the deflections were greater than when placed above the bar in the path of the waves into the positively charged and less cold atmosphere. Again, at north 80 degrees east the needle was in the path of waves directed by the earth, and here the deflection was greater than at north 80 degrees west, where the billows propagated by the bar flowed against the chains of waves directed by the earth. Of course, the sun's heat acts as any other heat; but Christie's conclusion that the light of the sun exerts an influence of repression or repulsion which produces movements of magnetic needles not accounted for by the influence of the sun's heat, is most interesting as an anticipation. For scientists and philosophers are beginning to talk and to write of "the push of light" and of

"some power of repulsion possessed by the sun" that is not yet understood.

That pulses in the ether, directed by magnets, influence light-producing waves, is not an hypothesis, but a recognized fact. That the converse is true requires no proof. But in the present study it is desirable for the reader to attentively consider the facts on which the proposition rests, and in view of which the postulate is clearly admissible. This field of observation and of thought has been gone over repeatedly by the leading physicists since about the middle of the fourteenth century, and there is no lack of pertinent proofs and statements from the most reliable sources. But the present writing being for readers who have not specialized in physics, and the writer's point of view of the facts being somewhat different from that of our recognized authorities, the evidence may as well be presented in the language of the scientific specialists. Besides, each quotation will have an interest of its own.

Hermann Ebert, Professor of Physics in the University of Kiel, in his work on *Magnetic Fields of Force,* in Chapter VI., Section 120, under "Axial character of magnetic lines of force," says:

" . . . We may conceive of the directional properties of a magnetic field as being brought

about by the flow of something along the lines of force. We have already made frequent use of terms which are based on this conception, though at the same time we have pointed out that this flow of the lines of force is only a mode of representation. There are certain phenomena which show that we have not to deal with this simplest form of vector, but with vectors of a different kind. For example, there is the rotation of the plane of the polarization produced in a beam of plane-polarized light which is made to pass through a magnetic field along the direction of the lines of force (Faraday)."

Dr. James Walker, Professor of Chemistry in the University of Edinburgh, in his *Introduction to Physical Chemistry,* Chapter XIV., pages 145-148, in discussing the "relation of physical properties to composition and constitution" of chemical compounds, makes the following statements:

"Some liquids exhibit the phenomenon of *optical activity;* that is, when placed in the path of a polarized ray they rotate the plane of polarization in one sense or another. Substances which rotate the plane of polarization in the direction of the hands of a watch are said to be dextrorotatory; substances which rotate it in the opposite direction are said to be

lævorotatory" (p. 145). "We are obviously here concerned not so much with the molecular volume of the liquid as with the average distance between the centers of molecules, the ray of light passing in a straight line through the liquid, and meeting a number of molecules proportional to the cube root of the molecular volume. Since the rotary power varies with the temperature and with the wave length of the light employed, it is necessary to specify both of these in stating the value of the specific or molecular rotation. . . . No altogether satisfactory answer has yet been obtained to the question of what determines the value of the molecular rotation in any particular case" (p. 146).

"All liquids when placed between the poles of a magnet or in the core of an electro-magnet become optically active. The character of the *magnetic optical activity,* however, is essentially different from that exhibited by liquids which are naturally active. If we place a tube containing a naturally active liquid between the prisms of a polarizing apparatus, and so adjust the prisms that no light passes through the system when we place a light-source at one end and the eye at the other; and if we then reverse the position of the light-source and of the eye, we find that the passage of the light

is still obscured. The sense and magnitude of the activity, then, are independent of the direction of the light. A naturally inactive liquid in a magnetic field behaves quite differently. If we first adjust the prism so that no light passes, and then reverse the position of the eye and light-source, we find that light now traverses the system quite freely. We find, in fact, on readjusting the prism to darkness, that a substance which appeared originally dextro-rotatory is now to an equal extent lævorotatory. . . . A magnetically active liquid is similarly dextro or lævo rotatory according to the direction in which the light passes through it, the magnetic field being supposed constant."

"Researches on the conduction of electricity through gases have led to an electrical theory of the atom which is of interest. The kathode rays emitted from the kathode of a Crookes vacuum tube behave as if they consisted of streams of minute particles charged with negative electricity and moving with a velocity comparable with that of light. They are deflected by a magnet, and from a knowledge of the extent of this deflection by a given magnetic force, and of the electric field in which they move, their velocity and their electrical charge per unit mass may be calculated" (Chap. XX., p. 218).

These citations are chosen to set forth that a magnet is capable of exercising a directive influence upon light-producing ether waves, whether the transparent element be solid, liquid, vaporous, or gaseous. Now, it is competent to consider the questions whether, in each of these cases, the molecules or only their electronic charges are rotated, and whether they, or either of them, oppose resistance to the light and change its direction without themselves being rotated. Hence, it would also be competent to consider whether the magnet influences the direction of the etheric pulses mediately or immediately. However these questions might be answered, it is certain: (1) That the magnetic pulses enter the elements in the same sense as the light pulses, and with superior potentiality in respect to the rotation, and (2) that they must be homogeneous.

In the solid prisms, where the material molecular structure has the more fixed form, it is conceivable that only the electronic charges are shifted somewhat as the blaze of a candle is shifted and held by a breeze. In liquids, where the molecular freedom is greater, it is conceivable that both electrons and the molecule involved are rotated. But in the Crookes tube, where residual gas and vapor particles—ions, consisting of minute particles of matter and

electric corpuscles—are being carried with the velocity approximately that of light by chains of etheric waves, and where the entire stream is diverted by the magnet, the conclusion can not be avoided that the magnetic waves have encountered the light waves and have changed their course in such manner as a stream from one yard hose might encounter a stream from another yard hose, the direction of both streams being changed by the impact.

That magnetization, magnetism, and magnetic effects are due to the activity of the ether is evident: (1) From the fact that extra-terrestrial agents and conditions produce them. All that has been said of the influence of the sun, the moon, the other planets, and the stars, in connection with the behavior of magnets, clearly shows this to be true. (2) From the fact that the ether is the only medium occupying inter-planetary space that is adapted to transmit the motions which occasion them.

That they are produced by those actions of the ether which are connoted by the terms *waves, pulses, billows, commotion,* and *agitation,* is evident: (1) From the facts which show a direct relation between the increase and decrease of these actions of the ether and the increase and decrease of magnetization, magnetism, and magnetic effects, and (2) from the

fact that the magnetic condition of the earth in the polar regions—particularly at sun-spot periods—are so related to the luminous circles and bands which surround the magnetic poles as to show a common origin of light and of magnetism. Here the quotation from Professor Proctor in the foregoing chapter may be recalled. With reference to the "luminous phenomena of the poles," in the volume already quoted, Dr. Ebert says:

"They are a direct visible expression of the magnetic condition of the earth, and are so especially related to the variations of this condition that they were justly called by Humboldt 'magnetic tempests' (*magnetische Ungewitter*). When a magnetic storm passes over the earth, and the magnetic needles are set trembling, the lights at the northern and southern poles, at no time quite extinguished, become especially brilliant."

This author proceeds further to show, what "numerous and careful observations have established": (1) That the streamers or rays of the aurora are everywhere nearly coincident in direction with the magnetic "lines of force." (2) That two rings (according to Nordenskjold) surround the magnetic axis of the earth like two candle-rings whose profile follows the "lines of magnetic force," and (3) that the

visibility of the so-called polar light is conditioned by the directions taken by "the lines of force" in relation to the beholder. In brief, without intending to do so, he points out that light-producing ether waves move in the same directions as magnet-producing ether waves move.

In view of these and numerous other facts almost equally convincing, we are secure in the conclusion that, if light and heat are due to etheric commotions, so also are all the phenomena of magnetism. Henceforth, then, such phrases as "lines of force," "energy of rotation," "energy of translation," "energy of heat," and "energy of motion," which have "filled a long-felt want," should give place to expressions adapted to convey more precisely the idea of the ether's agency in the physical conditions to be explained, especially since the truth of the matter is simpler and more easily comprehended than these vague expressions for an unknown cause.

Before passing on from the consideration of the causes of magnetic effects, it is desirable to advert to the occasions of etheric vortices and of repulsion and attraction. Experiments have shown that vortices occur along a straight conductor of electricity. Further, it is shown that the helix-like whirl along the single-wire

conductor persists when the wire is wound into a coil. Of course, whether the coil be a solenoid or a relay of insulated wire, the direction of the current along the wire takes the form of a helix. A fuller elucidation of this vortex motion and of its results in repulsion and attraction should here be given.

Uniformly changed motion in any sense requires at least two agents or conditions, the moment of the one affecting the moment of the other. A straight conductor, whether in the vertical or horizontal position, or at any angle between this and that, is in the path of ether waves directed by the atmosphere and the earth. The electric current, so called, acting in the conductor by means of, and along the chain of, etheric pulses propagated by the battery or the dynamo with which the wire is connected, responds also to the earth-directed pulses. Torque and spiral motion follow. Vortex motion is a modification of this, and the conditions are precisely such as to change the direction of the chains of waves lying nearest to the wire so as to produce vortex motion. That is, they move as with the threads of a screw, advancing towards the point of it. Each wavelet is instantly followed by another having the same direction, with the result that any paramagnetic substance, not itself in a state of magnetization

or not in a position to oppose these convergent waves with self-directed pulses, will be driven into the vortical center. This is the nature of magnetic attraction. It is already seen to be an inevitable result of counter repulsions.

As has been stated previously, Lord Kelvin, Clerk-Maxwell, Sir Oliver Lodge, and others, have conceived and developed a notion of the permanent rotary motion of molecules; and, to make sure of the permanency of the rotation without any means of sustaining the motion, they have very thoughtfully invented a molecular region where "frictional influences are absent." In this assumption modern philosophers find a *genesis* in which they can believe, and a source of *"energy"* sufficient to account for all natural phenomena not accounted for by the Nebular Hypothesis, the Kinetic Theory of Gases, and the Doctrine of the Conservation of Energy. Dr. Ebert relates that, in 1893, Helmholtz prepared an address, to have been made before the Scientific Congress at Nuremberg, but which was not delivered because the Congress failed to meet, in which he intended to discuss *"Permanent Motion as Apparent Substance";* and Lord Kelvin, upon Maxwell's assumption of the permanent rotation of the smallest conceivable particles of matter, made models to show how a system of gyrostats

may have properties identical with those of an elastic solid. Thus automatic, frictionless, atomic, and molecular rotation, vortices, and gyrations are made to account for the constitution of matter, as well as for the energy required to operate the universe.

It is quite possible, it is even very likely, that atoms and molecules of liquids, vapors, and gases are made to rotate under the pressure of etheric waves; and, if so, the rotation takes place in conditions comparable to those in which pebbles are rolled on a seashore by incoming and receding waves. For, in the first place, one should neither presume nor feel inclined to dispute the evidence of it disclosed by the specialists; nor, in the second place, is there any occasion to adopt a perpetual-motion device to account for it, where the constituted agents of Nature are so evidently equal to the phenomenon observed.

Finally, let attention be directed to the subject of molecular rotation as it relates to molecular magnetism. If our thesis is tenable, it should appear that the matter, the electric charges, and the etheric waves, held to be indispensable agents, should produce these minute magnets in the same manner as the magnets of the larger masses are produced. The inertia of the matter is greater than the inertia of the

electric charge, and the ether waves encountering them are directed in a rotary sense. Thoughtful readers are apt to reach the conclusion that this must be the case.

It is not necessary to argue that matter is inert. This is taken for granted in all learned treatises on physics where the larger masses are considered; and as to the hypothesis of "molecular energy of translation" and "molecular energy of rotation," it can readily be shown that the indispensable condition of a frictionless sphere for these automatic activities does not exist—except in the minds of the authors of the hypothesis. These philosophers themselves declare that there is no ultimate atom of matter, or minute point in space, however small, in which the ether is not present. Then, it pervades the ion, which consists of the ultimate atom and its electric charge. It occupies all the conceivable space between ions. They admit that it acts on ions, and that ions react upon it. To quote again Mr. Tyndall's terse expression of this thought, "a capacity to accept motion from the ether, and to impart motion to the ether . . . are correlative properties"; and it is absurd both to attribute and to deny to atoms and molecules such a capacity. They can not move without resistance and, at the same time, by their resistance, move all things.

Electricity is also inert, but in a smaller degree. Every indication and every proof of hysteresis pointed out by Professor Ewing, the discoverer of this characteristic of the essence, is an evidence of its inertia. The fact that the time can be estimated in which an electric impulse will traverse a conductor, is a proof of its inertia. Though it has been said to act like an incompressible gas, and though its autantitopy is amazing, it still exhibits a quality comparable to elasticity in familiar substances; and an estimable time is required for an electron to set its neighbor in motion. This is evidence of inertia.

Now, when an etheric flux of the minutest waves encounters a molecule, the waves meet greater resistance in the electron than in the adjacent region; their tangential direction has the effect of—or a tendency to—carry away a portion of the charge; the matter resists, and two velocities result in vortex motion. Hence, all the conditions are present which are found in the magnetization of larger bodies of matter. The vortex motion is not necessarily that of the matter, nor of the electronic charge; but it is always a whirl in the chain of ether waves.

The *magneton* is just now claiming attention as a newly discovered constituent of matter. From all accounts of it thus far pub-

lished, it is about of equal standing with phlogiston. Until all the alphabet "rays" are discovered and designated (which are no more in the class of thingy things than light and heat), such "discoveries" as that of "magneton" may safely be sent to Copenhagen for confirmation.

IX.

The Ether and Gravitation.

That matter, whether in a visible mass or in a molecule, has capacity to alter the direction of ether waves need not be dwelt upon to prove this a tenable proposition. Any one who accepts the wave theory of light and who has looked into a mirror, or who has observed the appearance of his fingers when immersed in clear water, or who has noticed the apparent changeable position of small objects on a dining-table when seen through a cylindrical glass filled with water, or who has watched a gold-fish swimming in a transparent aquarium of globular form, or who has perceived that double images of objects are made on the retina when they are seen through windows glazed with small squares of beveled glass, can assert from his own observations that ether waves are deflected by matter in a great variety of ways. The facts mentioned on page 137 relative to the rate of speed at which sound waves traverse different substances, show clearly that different elements have different capacities for impeding ether waves; and this points to the great truth

here being set forth, that matter resists the ether and is resisted in its motions by the ether.

That ether waves have capacity to move matter—to act as the *vis a tergo* of its translation—is also a fact which comes within the range of common observation. Heat in every conceivable form is a result of "etheric billows." The etheric billows which produce heat rend atoms and molecules asunder, dissolve substances, convert solids into liquids, separate liquid masses into vaporous particles, and drive these particles away in every conceivable direction from the seat of etheric agitation. Allowing for the activity of other co-operating agents, every motion produced by heat—by fire, by steam, by sunshine, and by combustion of every sort—is a demonstration of the proposition that ether waves have capacity to move matter, and that they actually impart motion to matter in innumerable ways.

But, so far as any demonstration has been elucidated, the mode of its imparting motion to matter—or to electricity, it is safe to add—is by pulsion, and not by attraction in the sense in which attraction is commonly conceived of and defined. To make this evident is the purpose of the present chapter. It is freely admitted that the modes of motion and the principles involved have long since been perceived and

described, some of them by one and some by another of the group of great scientists of the rank of Fraunhofer, Kirchhoff, Swan, Angstrom, Zollner, Clausius, Helmholtz, Hertz, Faraday, Kelvin, Maxwell, Tyndall, Joule, Huggins, Ewing, Scheiner, Richarz, and Ebert, whose names make merely a representative list. What is particularly aimed at here is, to show—what none of these has shown—that the ether is not merely acted upon by matter in motion, but is an active agent in the scheme of Nature operating to produce and to maintain these motions and conditions.

The aggregation of ions into atoms, of atoms into molecules, of molecules into vaporous particles, and of all these into larger masses, requires motion of the sort to be discussed. One condition resulting is familiarly called cohesion. But few persons understand that cohesion results from pulsion and resistance.

Resistance is the prime function of matter in the universal scheme, and it is an indispensable function. One could not walk were there nothing beneath his feet to resist his tread. One is enabled to stand erect through the resistance of the osseous frame in his body. Through the function of resistance the entire structural form of the body is maintained. Resistance is indispensable to both the form

and motion of matter. The absolute genesis of motion forms a distinct and highly important topic. Waiving a discussion of this for the present, motion may be imparted to one material mass by another mass of matter in motion, of course. The point made is, that in such events mutual resistance of the substances concerned is indispensable to the imparting of the motion. When electricity acts on matter, producing motion, matter reacts on electricity. When the ether of space produces electrical phenomena, electricity reacts on the ether, of course. However negligible the inertia of these subtile essences may appear to be, upon their mutual resistance and the resistance of matter all natural phenomena depend.

To convey an idea from a single instance of the ether's resistance, that to which the total sunlight is due is estimated to be equivalent to a continuous exercise of about twelve thousand horse-power from every square foot of the sun's whole area. Only a small pencil of this falls on the earth; yet, upon the resistance opposed to it by the terrestrial elements depend all the light and heat enjoyed on our planet. But our sun is only a comparatively small orb among the countless suns that are throbbing in the ether of space, and that are perpetuating the total ethereal commotion upon

which the phenomena of the universe depend. The etheric resistance which is manifested as magnetism, cohesion, and gravitation, for instance, is so immense as to transcend all human power to estimate it.

The way in which ether waves produce magnetism has been pointed out. That cohesion is an effect of magnetism is obvious. The almost infinitely small particles—the ultimate atoms—being magnets, and molecules being magnets, the formation of molecules and of masses composed of molecules, is an orderly aggregation of magnets. The words *cohesion, magnetism, and gravitation* are convenient terms, because they connote different aspects of the natural process now under consideration; but it is to be borne in mind always that the conditions which they indicate are homogeneous, being produced by the same agents operating in the same way.

There are different degrees of cohesion. The solids differ in the intensity with which their particles cling together. The cohesion of particles in solids is more intense than in liquids. Again, liquids differ, as do solids, in the intimacy of union betwen their particles. Still again, the molecules of liquids are more intimately united than are those of gases. It has already been shown that these differences arise from different degrees or modes of elec-

trification. Of all these, the gas particles are most voluminously charged. The phenomena of attraction between electrified small bodies illustrate the same process in the next step of separation; and the attraction between worlds illustrate the process in its widest range of operations. In every case magnetism is the bond. In every instance the ether operates as the *vis a tergo*.

In electrolysis one may witness the process of cohesion under the operation of the agents to which it is due. A so-called current of electricity, impelled by ether pulses directed along a conductor from a magnetic center, passes through the metal being dissolved and carried through the electrolyte to the object with which it is to cohere. The anions let go under pressure of etheric and electric pulses. By the same agents they are pushed through the electrolyte. The metallic particles set free into the solution yield up their charges to the non-metallic elements, and the latter are enabled to resist the gravitational current. They collect about the anode in a manner analogous to the levity of the atmospheric gases. The more nearly discharged metal particles gravitate to the kathode as they would fall to the earth were they not being carried through the solution by the especially directed ether pulses. The nascent

particles in the solution collect upon the kathode, which is oppositely charged; and, having been magnetized while in their discharged condition, they cohere in the intimate way of other particles in solids. Cohesion is a result of molecular magnetism.

The objection may be made that the process involves disintegration at the anode, and an explanation may be demanded as to how the same pulses which push *asunder* on one side of the electrolyte, could push the identical particles *into union* on the other side. An illustration may be taken from the actions of other and more familiar waves. Vessels are dashed to pieces by the waves of the sea, and seaweeds are torn asunder by raging billows; and, presently afterwards, the wreckage of the vessels and the debris of the sea-growths may be found in a single mass accumulated on the beach. The resisting shore plays its part in the accumulation. The conditions under which the rending asunder occurred and those under which the aggregation took place, are different in important particulars.

Nothing else in physics is more interesting than the behavior of ether waves in the presence of substantial resistance. The several critical points of temperature are instances. That freezing begins against solids is another. The

critical points of magnetization will be recalled by the reader. The facts that contraction, expansion, the weight of the mass, the atomic weight, the molecular weight, the specific gravity, the magnetization, and the cohesion of matter, are all influenced by temperature, should suffice to fix attention upon the great truth that the ether has a definite relation to each of these conditions of material substances.

Professor William Ramsay, of University College, London, in his work on "The Gases of the Atmosphere," after saying that "we are ignorant whether mass is changed by alteration of temperature," makes the following statement, which suffices in lieu of the particulars alluded to: "Experiments made by Sir John Airy, and interpreted by Professor Hicks, appear to show that variation of temperature is not without some influence on gravitational attraction. Others by Professor Laudolt point in the same direction."

It need not be argued that weight and gravity are due to the same agents. Remembering always that temperature is due to the action of the ether, the foregoing relates exclusively to the ether's agency in connection with weight and gravitation in general. It is interesting to find that Sir William is much more decisive in pointing out the relation

between weight and electric charges. He says:

"Now, Faraday found that when elements are deposited, equal quantities of electricity are conveyed either by equal numbers of atoms or by some simple fraction of these numbers. To this fraction we apply the term *valency*. Thus we say that an atom of oxygen is bivalent, or a dyad, because it conveys twice as much electricity through the liquid in which it is present as an atom of hydrogen, which is termed univalent, or a monad. *Here we see a direct connection between the conveyance of an electric charge and the atomic weight.* The electric unit of quantity is in fact defined as that which can be conveyed by a certain weight of hydrogen, by eight times that weight of oxygen, by 108 times that weight of silver, and so on."

There are many curious facts pointing to the relation between electricity, the ether, and gravity, that become explicable when the view is taken which admits these essences to be the agents to which gravity is due. In Chapter IV., on page 88, mention is made of osmose as an electrical phenomenon. The rise of the heavier elements in a solution through the lighter to higher altitudes, and the falling of the lighter elements thereof through the heavier to lower altitudes, which movements appear to be against gravity, are estimated to require enormous pres-

sure. Nerst calculated that the force required to drive a gram of dissolved urea through water at the rate of one centimeter per second, is equal to a weight of forty thousand tons. Yet, it is known that metals having the greatest atomic weights move with the greatest speed in the osmotic migrations just mentioned above. This is simple enough when it is remembered that they are most susceptible to magnetic influences, and that, within the limits of the solution or gas of the osmotic phenomena, the united influence of neighboring molecular magnets is greater than that of the earth upon the atoms involved.

The curious thing in osmosis is the lifting of elements apparently against gravity. This happens in ebullition, or boiling. The facts that compounds with the highest molecular weights have, as a rule, the highest boiling-points, not only indicates a direct relation between etheric commotion and molecular weight, but points also to the *vis a tergo,* the *pushing force,* which characterizes all gravitational phenomena the processes of which we are permitted to follow throughout. Here, again, the locally directed pulses of the ether have greater influence than those passing from remoter causes through the boiling substances towards the center of the earth; and, in this respect, the process is com-

parable to that in osmosis, to that in electrolysis, and to that in magnetization.

Cohesion in the process of welding metals results from the essential conditions of molecular magnetization. First, the white heat of the two metals to be welded brings them into the like condition of temperature, too intense for ordinary magnetic effects; but in this condition their particles can intermix as those of other fluids. At the same time, the heated metals, having given up much of the primitive molecular charges to the surrounding elements, are made the more susceptible of magnetization when the temperature falls to the critical point at which, and below which, their molecular structure is influenced by magnetizing pulses. Then, in the absence of such charges as would prevent cohesion, the molecules are forced into the most intimate union possible. The process of their falling together is identical with that in which molecules of water take the form of ice. That is, the metals of common use *freeze* at temperatures much higher than the degree at which water freezes.

It is most instructive to consider the solidifying of fused metals with a view to the influence of temperature in the process. Water freezes at 273 degrees above absolute zero, where etheric agitation is supposed to cease.

This critical point marks the death of matter. Below it no natural change can occur. Therefore, *solidification always takes place at some stage of etheric commotion.*

It has been mentioned that freezing begins in connection with solids. Water may be cooled to four degrees below freezing without solidification taking place; but the introduction of the very smallest crystal into the superfused liquid occasions its crystallization; and this is the case even when the crystalline particle is so minute as to be unrecognizable by any ordinary means (Walker). Investigations in relation to this have led physicists to conclude that hailstones must form around solid particles of non-aqueous matter afloat in the atmosphere. The reason is not far to seek. Even the minutest solid, being accompanied by its primitive charge, has sufficient inertia to resist an ether wave and to start a whirl about itself as a center of magnetic effects.

It is worth while in this connection to advert to the various effects of waves as witnessed in water and other well-known liquids. A billow that gently lifts a lifeboat, crashes against the side of an ocean steamer with tremendous force and awful noise. It recoils from the impact in spray and foam. It causes the great vessel to plunge and roll. It alters the direction of the

greatest ships. It produces tremors and thrills which run through all the beams and timbers of the largest crafts. It smashes the more frail objects on deck, and accumulates them in heaps about the masts. The resistance it meets results in friction and heat, in various sounds, in different motions, in disintegration, and in aggregations. Yet, we are here enumerating only the effects produced by an ocean wave of the greatest length and velocity. Surely it is not unreasonable to attribute to the infinite variety of pulses in the ethereal ocean analogous and equally numerous effects.

Ships of steel, wooden crafts, and masses of seaweed will float along at approximately the same rate of speed on an ocean current; but if a resistance not overcome by the current should check the movement of the ship and the seaweed, it would be perceived at once that the latter would oppose much less resistance to the onflowing current per unit volume than the ship. Being less dense, the seaweed would allow the water to flow through its mass with little resistance. In like manner all bodies fall with like speed when carried by the ether without resistance; yet, when stopped by the earth, their weight is found to vary according to their several densities, or in proportion to the number of atoms per volume.

There is another aspect of the accomplishments of ocean waves in which this illustration is carried somewhat further. The writer, having lived several years in the West Indies and in Hawaii, is able to vouch personally for the truth of the observation about to be given. If any one will take the trouble to attentively pursue the coastline of any island in mid-ocean, he will find sand, pebbles, bowlders, and drift of wreckage of many sorts at all points along the shores. The direct impact of the waves, which assail the islands from all directions, is always more forceful than the recoil, and the result is that the resisting solid in the midst of the ever active liquid becomes a center of gravity upon which the oceanic accumulations are made. Even the abundant material brought down to the sea by streams, is beaten back till deltas and broad savannas are formed where aggregation conquers disintegration.

It is interesting to note how uniformly simple, and how effective in her simplicity, Nature is throughout her operations. In closing his little volume on "Modern Views of Matter," Sir Oliver Lodge says: "All we have to do is to ascertain by careful and patient investigation what really happens; and my experience has led me to feel sure of this, that whatever hypotheses and speculations we may

frame, we can not exceed the reality in genuine wonder. And I believe that the simplicity and beauty of the truth concerning even the material universe, when we know it, will be such as to elicit feelings of reverent awe and adoration." The true scientist is a worshiper.

Turning now from the observation of gravitational effects in the local sense, if we direct attention to the processes by which the ether and electricity accumulate matter upon planetary centers, and by which they maintain the positions and motions of celestial bodies, no differences of method will be found to complicate the universal scheme. The same agents are found to be operating in the same ways, and the same amazing simplicity and uniformity of plan characterize the vaster systems.

The wave theory of light is so well established, and the various phenomena of light have been so accurately ascertained, that the behavior of etheric waves to which light is due may be confidently pointed to in explanation of the behavior of those waves to which other phenomena are due. It is well known, for instance, that reflection and refraction are common in the phenomena of radiant heat, light, and sound; and, as Hertz and others have shown, electromagnetic waves are reflected, refracted, and polarized in the same way as those of light.

As early as 1850, Jean Foucault, the French physicist, proved that light waves move at a slower rate through water than through the air or in a vacuum. Here is material resistance to etheric waves. Professor A. A. Michelson, German-American physicist, has ascertained the ratio of the velocity in air to that in water to be 1.33; and the ratio of the velocity in carbon bisulphide to that in air to be 1.77. Here is variable material resistance. Again, Michelson has proved experimentally that the speed of red-light-producing waves is 1.4 per cent. greater in water and 2.5 per cent. greater in carbon bisulphide than the speed of blue-light-producing waves. Here is a difference of potential between ether waves of different lengths. Still further, by the aid of these facts, observations have been made upon stars of white light at occultation and at emergence from behind the moon; and it has been found that light-producing waves of all lengths travel through the ether at the same speed. Otherwise, lights of different colors would appear to the beholder as an occulted star emerges from behind the moon, or when an eclipsed moon of Jupiter reappears, or when the bright component of Algol whirls into view from beyond its dark companion once in every three days; for if the speed of red-light-producing waves were

greater in the inter-planetary medium, for instance, the emerging star would flash out to us a red signal of its escape from the eclipse.

The speed of light-waves through the ether, as determined by Michelson and Simon Newcomb (the latter of the United States Navy), about 1880, is 186,327 miles per second. Waves propagated by the sun require approximately eight minutes to arrive upon the earth. This shows that the ether itself is appreciably inert. In this fact we have the complement of all conditions necessary to resistance between ethereal billows and matter in every form. As to resistance between the ether and electricity, since the idea was suggested by Clerk-Maxwell that light waves involve electrical displacements at right angles to the direction of propagation, evidences of the truth of this have constantly accumulated; and, at the present time, even the boy amateurs in wireless telegraphy apprehend the mutual resistance of these two essences.

Now, in the light of all this, witness the approach of a comet towards the sun during perihelion. Its nucleus consists of a cluster of meteoric stones, as there are very good grounds for believing, and it is enveloped in a vast atmosphere of attenuated gases. When first seen it is nebulous and dim. As it approaches nearer to the sun the nucleus contracts, the

solid fragments being driven together by the force of the waves from outward sources which are driving it back upon the sun and by the far more intense pressure of the waves from the sun. The widely scattered particles in its atmosphere, which consist of dust, begin to cluster about the nucleus, especially on the sunward side, forming the bands that are commonly called the head of the comet; and its atmosphere, which is rich in the electrical component of all atmospheres, lags away to aphelion and scintillates in the region beyond the nucleus from the sun, where the meeting billows that sweep around and through the nucleus produce the luminous effect. Under the impetus received from without, it hastens with accelerated velocity to its perihelion passage, its atmosphere and every element of its content contracting so rapidly as to be profoundly chilled in the very face of the sun; and then, receiving a new impetus for its next journey to the outposts of the Solar System, it darts away with its searchlight directed toward "the region of outer darkness."

All the phenomena attending the perihelion passage of comets indicate pulsion, repulsion, resistance, compression, contraction, and electro-etheric activity. Whatever may be the truth about the luminous phenomena of comets, they

make it possible to form reliable judgments as to the way in which the material elements of these bodies arrange themselves; and it is certain that the dominant force in this arrangement proceeds from the sun through the medium of the ether. Fedor A. Bredichin, of the University of Moscow, found hydrogen gas in the long, straight rays which extend furthest from the nuclei, where he estimated the solar repulsion to be from ten to fifteen times as great as the attraction of gravity. Where it was only a little more than twice as great he found what he supposed to be hydrocarbon gases. Still nearer the nuclei he found metallic vapors of considerable density. Of course with him, as with all philosophers since Sir Isaac Newton, "the attraction of gravity" is an inexplicable property of matter by which bodies of all dimensions are drawn towards one another at all distances of separation. This "pull of gravity" is a fiction founded on apparent rather than real facts, like the notion of the *rising* and the *setting* of the sun; and, in the light of accumulating evidence, it must go the way of Ptolemaic epicicycles and of phlogiston. So, like Scheele, Cavendish, and Priestly, while still holding on to entrenched erroneous conceptions, our modern physicists and astronomers are slowly, but surely, relegating to oblivion some

of the most reverend "scientific conclusions" of their distinguished predecessors.

It is well to note in passing that the arrangement of the material elements of comets according to the resistance which each element opposes to the etheric pulses, as shown by Bredichin's discoveries, does not place the nucleus in the midst of the cometic body, as planets float approximately at the center of their atmospheres. The nucleus of a comet being exceedingly small in proportion to its enormously large atmosphere, and the gaseous component being more readily resisted by the repellent ethereal billows as perihelion is approached, the solid component, from inertia and momentum, arranges itself in an eccentric position in relation to the whole body, and nearer to the sun than it would be if it were at the center of its atmosphere. Nor does this argue that the general shape of a comet is that of its appearance to beholders on the earth. Indeed, there is plausible evidence that the electro-etheric center of these bodies—which is the potential center—is far to aphelion from the nucleus, both before and after the perihelion passage; for sometimes lagging matter of the nuclei develops shapes which take up positions in relation to the main body similar to the position of the comet in relation to the sun. This indicates that repellent

ether waves are propagated from the cometic center; and, if so, this is in harmony with all the facts which go to show that comets are probably self-luminous to a comparatively small extent. For the ability to produce etheric agitation of any kind establishes a presumption favorable to the notion that they may have ability to produce etheric pulses of every kind.

It remains to be shown that the direction imparted to ether waves by electrically charged matter, and the direction given to matter by ether waves in this wider sphere of physics, are results of actions of the same agents which produce our laboratory and familiar every-day results. Particularly, it is to be made evident that the motions of the planets—of all bodies that "wander" in the heavens—are produced in the same way as ordinary magnetic effects are produced.

X.

The Physical Cause of Planetary Motion.

Tentatively, let an electric light and power plant operated by a water turbine wheel be regarded as "a closed system." When the stream of water from the reservoir first falls upon the wheel, all the mechanical motions throughout the system are slow, though the buckets of the turbine receive water to their full capacity for being actuated by it. But gradually, without any increase of impinging water, every mechanical motion in the entire system is accelerated and every wheel in the system revolves with increasing velocity. This increment of motion, without an increment of motive power, has been carefully studied by philosophers, and has given rise to a number of conceptions which receive large measures of attention in modern physics, in every department of which they appear to be illustrated.

If a vessel placed over a flame of burning gas, and containing a gram of ice, be viewed as a closed system whose purpose is the production of steam, the operations of this system will show the like apparent increment in "the

total energy of the system." As has already been mentioned, the melting ice and the water in contact with it will continue at the melting-point temperature until all the ice is changed to water. The notion that the "energy of heat" has been imparted to the system without increasing the temperature, taken in connection with the notion that "energy can neither be created nor destroyed," gave rise to the conception of "the energy of latent heat" as the "form of energy" being stored up in the system. The tendency, however, is toward an increase of molecular motion; and the step-by-step progress continues as the critical points of melting, boiling, vaporization, and dissociation are passed, till the maximum of molecular motion is attained. In observing this process, and especially in the attempt to formulate a "law" for it, Clausius, to whom the scientific world is so much indebted for the principles of Thermodynamics, was not content to say merely that "the energy of a closed system tends to a maximum." His view was so large as to embrace every sort of mechanical system: for, in every system he considered he saw the *turning in* of energy, as well as the tendency toward the maximum results of the supposed accumulation and conservation. For the "turning-in" conception, he invented the word

"entropy," from the Greek *entropia;* and then he announced "that the entropy of the universe tends to a maximum."

In this masterly and all-embracing expression of his stupendous conception Clausius does not say—nor mean to say—that the *energy* of the universe is increasing, though he has been so misunderstood. He says only what he means, that the *turning-in,* upon the material component, the energy component of every closed system, always tends to a maximum result of this *turning-in.* But the masterfulness of his conception is all the more remarkable in the view of it that he expresses comprehensively, though vaguely, a great truth which he did not himself exactly understand. In spite of the vagueness of his term "entropy," his generalization will forever entitle him to the admiration of thinking men. But the inquiries, "Why this 'turning-in'?" and "To what agent is it due?" are perfectly legitimate, and must be answered before the profound generalization can be fully elucidated to any mind.

Equally far-reaching in scope, equally vague in expression, and also waiting for complete elucidation, is the so-called "law" that *"the energy of a system at rest tends to a minimum."* In the light (?) of this law, surface tension, capillary attraction, and kindred phenomena

are explained and misunderstood. Here, again, the inquiry, "Why this tendency when a system is at rest?" is legitimate; and the truth about it must be brought to light before we can be perfectly sure that it is profound rather than merely vague. Especially should students of Nature press the inquiry as to the agents to which this specious "law" is due.

In Chapter VI., pages 132-134, it was shown that human beings are incapable of devising "a closed system, which gives up no energy from within and receives no energy from without." It is equally demonstrable that, in the sense of the last-mentioned "law," where dewdrops and oil spheroids suspended in solutions are instances, no such thing as "a system of bodies at rest" has ever been discovered by a physicist. No physicist worthy of attention will admit that the bodies which form the system in a drop of dew are ever at rest during the tendency to the spheroidal form. Most physicists hold that every molecule and every atom in the tiny sphere is constantly in motion. The phrase "at rest" is wholly inadequate. Particularly is it inadequate as a description of the planetary spheres, which are moving through space at rates of speed from ten to fifty miles per second under such gravitational stresses as those which move the tidal waves

of the ocean daily, while the spheroidal form of each is produced and maintained by the same agents that shape the raindrops and the dew.

The clinging of electricity to matter and its integrative behavior have been mentioned in a previous chapter, where it was stated that every unit of electricity in association with a mass of matter is so arranged as to be as near as possible to the center of the material mass. An explanation of this mode of distribution was deferred till the evidences of gravitational ether pulses could be given. Now, since the push of ether waves is apprehended, and it is understood that ether wave-lengths vary from the dimension of an ultimate atom to that of a solar system, and since it is known that they fall in infinite numbers from all directions, alike upon dewdrops and worlds, the reader will understand that the elements of the drop and those of the planet are shaped into spheres by the incessant and approximately uniform pressure of "ethereal billows." Even the "atmospheric lenses," those "air clots" which hinder the work of astronomers, and "acoustic clouds" which deflect the sound-waves of signal guns and sirens in all kinds of weather, are given their shape by this universal medium. It is needless to state more fully than has been intimated

that this shaping in every case takes place while "the systems of bodies" so shaped are in motion, and are under all the stresses and strains peculiar to their environment, whether they be hailstones, raindrops, molten metal, or worlds in a state of igneous fusion.

A simple experiment with one or with two horseshoe magnets and an annealed iron ring will make evident the direction taken by magnetic waves when they encounter a material mass. If only one magnet is used, pierce a board with two holes through which the poles of the magnet may pass. Let the holes project above the board so as to be flush with the surface of the iron ring when it is laid between them. If two magnets are used, they may be laid flat on a table with like poles fronting one another, but arranged far enough apart for the ring to lie between the poles without being in contact with the magnets. Place a white paper over the ring and the magnet or magnets, and then sprinkle iron filings upon the paper. Tap the paper lightly, causing the filings to leap from the paper through very small intervals, and the so-called "lines of force" will redistribute them so as to make a diagram of the course of the chains of waves from the magnetic centers as the ring is being traversed by them. Little curves will be formed which will arrive upon

the ring perpendicularly, as gravitational waves fall upon the earth. By approaching a mass from every conceivable direction thus, etheric waves shape it into a sphere which is invested by an electrisphere. They are condensed upon the spherical center of gravity as light-waves are condensed by the lenses of the eyes.

Now, every electrisphere, whatever its dimensions may be, opposes its individual resistance to all waves impinging upon it; and hence, every charged particle and every charged mass of matter belonging to a planet contributes its share to the resultant motion imparted to that planet by the action of the ether upon them all. Besides, the essential phenomenon of "turning-in" of energy of every planet and every system in the universe, is due to the action of this all-pervading agent, as will now be illustrated and shown.

Suppose a column of children to be marching over a region that is marshy and very difficult at the center of the column, but less and less so on either side of the central line of their course, the outer edges of the way being perfectly firm, smooth, and easily traversed. Suppose them to be arranged eighty abreast in one hundred transverse lines, being eight thousand in all; and fancy that the children in each transverse line are holding to one another's

hands, and that these lines are three or four feet apart. Now, if they advance at the highest rate of speed possible to each, the children in the center being impeded by the marshy ground and those nearer the ends of the transverse lines being facilitated by the firmer condition of the way, the lines will inevitably bend toward the axis of the marshy strip, on both sides of it; and presently the children at the two ends of each tranverse line will be meeting one another in the most difficult portion of the field. Ultimately those coming up behind will crowd upon those going before, and they will congregate into a compact mass at the meeting-point. The children may be equals in energy, and it may be assumed that each does his best continuously during the march. Then, the *energy* in the proceeding is a constant; but the "entropy"—the turning-in—tends to a maximum; and the capital result is congestion, aggregation, consolidation.

This illustrates an elementary conception of the "entropy" resulting from the impact of ether waves falling upon our planet. The advancing column of waves is eight thousand miles in cross section, this being the diameter of the earth. Those in the center of the column are first to meet the resistance of the atmosphere and of the globe. This resistance con-

tinues at an increasing rate through four thousand miles, or half the diameter of the earth, before the incidence of the rays at the surface of the column. Imagine a line of waves arriving abreast parallel to the terrestrial meridian at Greenwich, or parallel to the equator at Victoria Nyanza. The speed of all waves through the ether being the same, the resistance of the atmosphere and of the globe would begin at the designated point; and all rays or chains of waves, except a comparatively limited number at the center of the column, would be bent towards the earth's center and towards the axis of the unbent rays. Here, then, is a "turning-in" of something which is effectual in overcoming inertia and in producing "motion of translation," as well as in producing compression, aggregation, and consolidation. Besides, since the succeeding waves accumulate upon the resisting center, this "turning-in" tends to a maximum.

It will be recalled that paramagnetic substances, expanding under the influence of heat-waves, ultimately reach a degree of molecular separateness in which magnetization either ceases or is very feeble. The converse is, that molecular proximity is favorable to magnetization. It is a fair inference that molecular proximity facilitates other effects of impinging

ether waves, and that gravitational pulses are effectual in proportion to the number of atoms and molecules within a given area, as well as to the condensation of the rays and the volume of electrical charges.

"We have no direct evidence to show that magnetic 'lines of force' have any definite cross-section; but a certain number of 'electrical lines of force' terminate at each atom" (Ebert). The deeper truth probably is, that the electric charge of the atom is the minimum unit of resistance in all magnetic and gravitational effects.

If the repellency of etheric billows were the only effect produced upon the matter of the earth, its condensation would be very much greater; and if the earth were the only body of matter in the sidereal field occupied by the Solar System, its place would be approximately that of the sun. For, in the first place, though the sun adds his repellent billows, his heat-waves largely counteract the contraction which would result from gravitational waves alone. For instance, at the poles, where heat-waves are less effectual, gravitational waves are 1/190 more effectual. That is, a mass of matter that would weigh 190 pounds at the equator would weigh 191 pounds at either of the poles. In the second place, the repellent waves from the sun expend their force largely in pushing the

planets out to their orbital distance from him, and in driving them along their orbital courses.

It has been held by astronomers since the time of Sir Isaac Newton (1687) that no force from behind is necessary to drive the planets along their orbits, but only a deflecting force acting toward the sun, to counterbalance their tangential force. This view is untenable for the reasons: (1) Broadly, that every known fact which shows the power of electricity to set the ether in motion, and every fact that shows the power of the ether to set electricity and matter in motion, shows that there is resistance between the ether and the electrically charged planets which move through it at such excessive rates of speed, and (2) specifically, that the whole solar region of influence is a magnetic field, which acts like a viscous fluid upon all substances moving in it, pointedly contradict this view.

"The centrifugal force of the planets," which was thoughtfully introduced into the Solar System to make "The Nebular Hypothesis" a "working hypothesis," is supposed to have begun operations "fortuitously"; and it is believed to perpetuate the orbital motions of all the planets by having given each its "energy of translation" when thrown off from "the original nebula." "Centrifugal force" is one of the

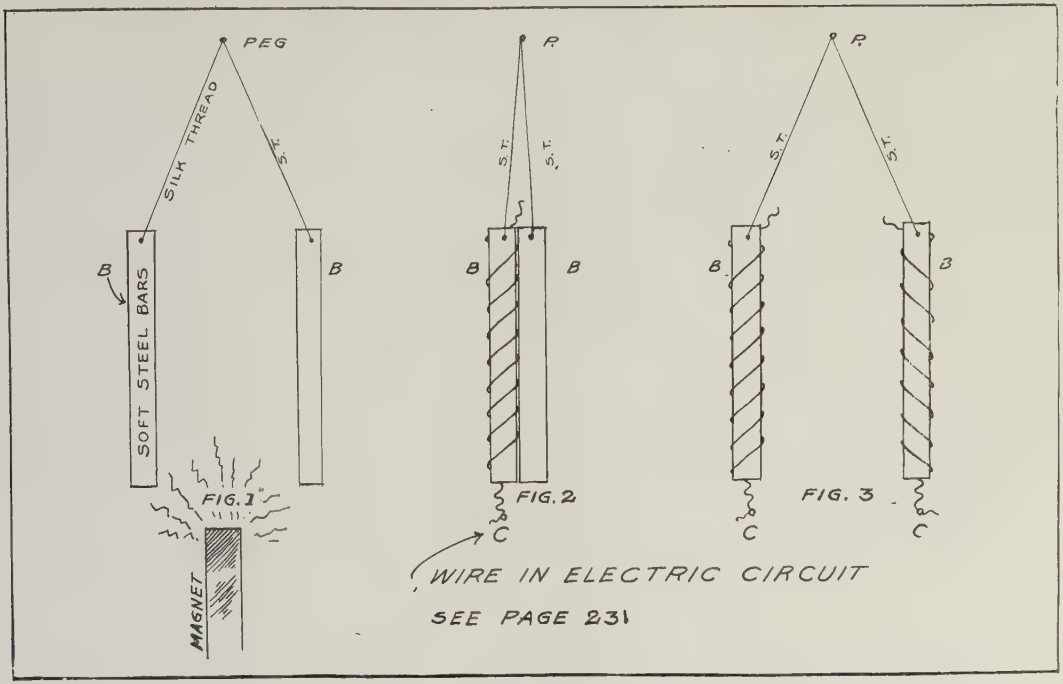
devices by which the Solar System is operated on the perpetual-motion plan; for it began without a cause and it proceeds indefinitely without friction. There is one fact that may be appealed to as showing a probability in its favor, by analogy: belief in it has persisted for several centuries without anything whatever to sustain it!

The "original nebula" was first seen by Swedenborg. When Laplace undertook to develop it into solar systems, it had already got —"fortuitously"—into vortex motion. Of course, a sort of embryonic "entropy" was the chief characteristic of this motion, as a "turning-in" is always characteristic of vortices. Laplace accelerated it gradually, and very greatly, with a view to the throwing off of nebulæ into space. Incidentally this required that a portion of its "energy of rotation"—a convenient product of modern invention—should be imparted to each of the rings; and, to give them adequate room in space, a certain amount of the original fortuitous "energy of rotation" had to be transformed into "energy of translation" for orbital purposes. Laplace made this transformation, and the original nebulous matter of the planets ran away with it from the central mass! Ever since then it has been operating as "centrifugal force," in college and university solar

systems, in all parts of this world. It is an occasion for profound religious gratitude that the philosophers who have supposed the orbital motions in the actual universe to be maintained in this manner, have never attempted to fix the responsibility for the scheme upon the Creator.

It is now understood and avowed by all learned men that the sun and all the planets are great magnets, and that "the lines of force" of these vast magnets operate in the same directions and in the same senses as do "the lines of force" of smaller magnets.

It is a capital fact that the polar axes of all these planetary magnets of the Solar System are arranged approximately parallel to one another. Advancing in a train, with this variable but constant relation to one another, all the bodies that encircle the sun move in an easterly direction along their orbits; and all of them which have rotary or diurnal motion, revolve eastwardly. All are moving at approximately constant distances of separation from one another, and the whole group is advancing along a course which may be called the orbit of the Solar System. No explanation of these relative positions and motions is tenable, therefore, unless it fully recognizes the influence of their magnetism upon one another; for, as is also avowed by the most learned scientists, "mag-


PEG
SILK THREAD
S.T.
B
SOFT STEEL BARS
B
FIG. 1
MAGNET
P
S.T.
S.T.
B
B
FIG. 2
C
WIRE IN ELECTRIC CIRCUIT
P
S.T.
S.T.
B
B
FIG. 3
C
C

SEE PAGE 231

netism is a bond between world and world."

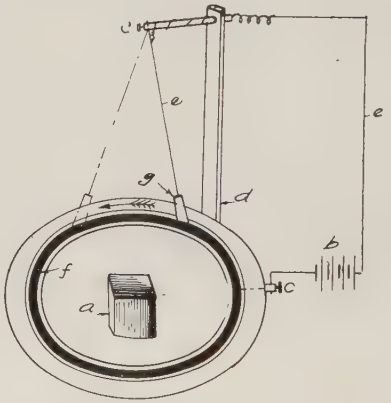
Pierce each of two thin, soft steel rods of about four inches in length with a small hole in one end, and suspend them by threads so as to cause them to hang parallel to each other and an inch apart. Bring near them the pole of a strong bar magnet, and they will move away from each other. The extent of this movement will be proportional to the strength of the magnet by whose rays they are repelled. They are being magnetized by induction; and, the like poles of each being opposite, the mutual repulsion is due to the parallel relation to each other. Wind one of them with a small insulated copper wire, known as magnet wire, and connect this wire with an electric battery so as to send a current around the rod. The other rod will be forced into contact with it by converging rays of the vortex whirl. Now wind the other rod, and send a current around it in the same manner, and they will be seen to move away from each other again. The extent of this movement will be proportional to the resistance of the current used. Of course, in both instances, this effect will be more manifest upon a paramagnetic metal than upon a diamagnetic substance of any kind, or upon any mixture of the two. Again, of course, the position taken up by diamagnetic substances in relation to

magnetic rays being different from that of paramagnetic substances, the inclination of the poles of a body thus magnetically influenced would depend upon the amounts and distribution of its material elements.

Here is a very clear and reliable instruction as to the way in which the repellent rays from the sun distribute the planets in their orbits and incline their poles to the ecliptic. Every planet, or system of planetary bodies, is pushed away from the great central magnet, and from every other magnetic center in the whole system, till a point of equilibration between these repellent rays and all those from remoter suns and systems is reached. The mean orbital distance from the sun depends upon the volume of the electrical component of the body in its proportion to the material mass, as was intimated in the chapter on electrispheres; for its susceptibility to magnetization depends on the molecular distribution of its matter, and this depends upon its electrification.

In 1870, M. Flamarion, through M. Delauny, presented to the Academy of Science an important conclusion as to the movements of rotation of the planets, in the form of a general "law," that in some senses harmonizes with and confirms the conclusions reached in this study. Seeing that the earth revolves in 24 hours, Jupiter

Orbit about a Magnet.



a, magnet; b, battery; c, binding posts; d, Standard; e, wire; f, trough of mercury surrounding the magnet to afford connection for circuit; g, amalgam pendulum dipping in mercury and traversing the orbit about the magnet.

in 9 hours and 55 minutes, Saturn in 10 hours and 16 minutes, and so forth, his astute calculations in relation hereto led him to suppose that their rotary motion is an effect of gravitation depending upon their densities, and that the rotation of a primary planet is equal to the time of the rotation of its satellite which revolves freely around its equator, multiplied by the coefficient of retardation, representing the density of the planetary body. This coefficient of relative density is, at the same time, for each planet, the square root of the ratio of the gravity to the centrifugal force. This "law" makes a distinct advance in the science; but it does not reveal anything of the actual agent to which gravitation is due.

Another very instructive experiment with magnets and electrically charged substances, devised by Faraday, illustrates how planets are actuated in their motions along their orbits, though he did not make the application in this sense. A wooden disk is pierced with an opening into which the north pole of a bar magnet is fitted. In a circle around the pole of the magnet a groove has been cut, to receive a ring of mercury. A wire that is part of a circuit is introduced into the mercury through the wood adjacent to the groove, so that the mercury may become a part of the circuit. Then

a slender amalgamated strip is suspended over the pole of the magnet by a loop in the end of it, so that the other end may dip in the mercury and continue the circuit through it. When the circuit is completed through an electric battery the amalgamated strip will rotate about the magnet, traversing the ring of mercury. There are many devices by which the cyclical direction of "the lines of force" about magnets may be shown. Certain of these lines may be described as "entropic"; that is, they "turn in" so as to pass through the magnetized substance. Some of them move along ellipses, the magnetized body being barely within their orbits, or else farther within, as they may be influenced by the outward environs. Other lines may be traced with the aid of iron filings upon paper placed over the magnet, so as to describe parabola and hyperbola.

It was one of Kepler's capital discoveries that the orbits of planets are ellipses having the sun as one focus. His conclusion was readily confirmed by astronomers, though neither he nor they knew the cause of this. It is indisputably one of the magnetic effects of the arrangement of the planets in relation to the sun. Again, there are comets which fall into those lines which describe parabola, and which —as astronomers are led to believe—never

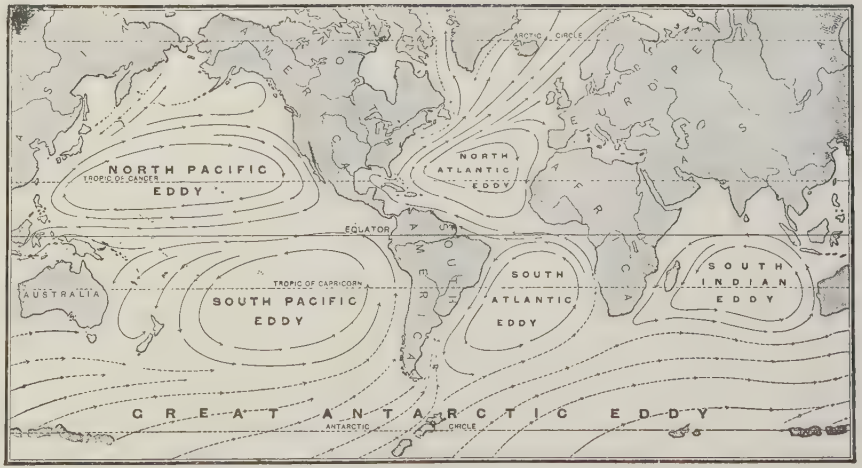


Chart of the Ocean Currents.

re-enter the solar domain. Thus the conclusion is borne out in every detail that the motions of celestial bodies are due to the action of the ether, and in particular to those pulses or waves to which magnetism and gravitation are herein ascribed.

In this connection a possible action of the ether may be suggested as a hypothesis. There may be currents in the inter-stellar medium comparable to the currents of the inter-continental oceans. A little reflection touching the causes of the latter will be sufficient to satisfy any thoughtful person that this hypothesis may be tenable. A few facts will facilitate such reflection.

We know that a complete system of circulation, vertical as well as horizontal, exists throughout the whole of the waters of the great Atlantic Valley (Proctor). The Gulf Stream exhibits the surface circulation; but deep-sea soundings have proved that there are also undercurrents whose courses are equally definite and the functions of which are equally important. Captain Wilkes, of the United States Exploration Expedition, found a cold undercurrent at the equator that is fully two hundred miles broad. The Gulf Stream begins at the Bight of Biafra, which is just north of the equator on the west coast of Africa; it

crosses the Atlantic to Brazil, by whose coast it is in part turned northward into the Caribbean Sea by way of the Isthmus; thence it passes to the West Indies, where it bifurcates; and thence it advances in two broad streams to the North Atlantic. But Dr. Carpenter showed, and Proctor agrees with his conclusion, that the depths of the Atlantic are traversed by vast currents which are much colder than the deep-sea temperature of the latitude, and which must be the returning waters of the celebrated stream.

Columbus was the first to notice that the equatorial waters "move with the heavens," or following the apparent motions of the sun, moon, and stars. This motion is, of course, merely relative to the surface of the earth; for the eastward displacement of the surface of the equatorial ocean, though less than that of the solid portion of the globe at the ocean floor, is approximately a thousand miles per hour. Still, relative to the solid globe, the Gulf Stream flows westward; and the occasion of this flow is the billows lifted up and retarded in their eastward proper motion by the magnetic influence between the moon and the water of our planet. In brief, ocean currents are set in motion along the axes of magnetic pulses; and it is a legitimate speculation that the ether may

be set in motion as the water of the ocean certainly is, and that there may be vast whirls in the ether corresponding to the orbits of planets and of systems in the universe.

Clerk-Maxwell, Lord Kelvin, Sir Oliver Lodge, and others, reached the conclusion, from evidences of ether whirls about atoms, that the material elements may have been formed and organized into molecular structures of them and by them. It is as reasonable to conclude that the ether swirls about a planet, as it is to infer from rotary motions of molecules that these minutest whirls exist. It is an equally rational suggestion that the diurnal motion of the planets may be actuated by such whirls. This, however, is not the only thinkable way of accounting for the diurnal motion of bodies having atmospheres. The centripetal influence alters the tangential course of the earth about one inch in every forty miles, or about one foot in four hundred and eighty miles. This fact points to a pressure from outward that is adequate for this alteration; and, though no rational explanation of the fact that all the planets rotate eastward can be given on strictest physical grounds, rotation in this sense having begun, the expansion of the atmosphere on the side of the planet receding from the sun and the condensation of the atmosphere on the side

approaching the sun, would become a constant condition.

Whether or not the real cause is here indicated, what might be expected to result from this condition is actually happening; for planets such as Jupiter, whose atmosphere is comparatively greater than that of the earth, rotate far more rapidly, and planets such as the moon (that has no atmosphere) move in their orbits around their primaries without revolving in the sense of the earth's diurnal motion.

But whether or not the ether itself moves in currents, or suffers any general displacements except such as may be described as vibratory, there remains no doubt in the minds of modern physicists that it is the great and indispensable inter-planetary medium; and, this being accepted as reasonable, the medium must produce its effects either by vibratory motion, or by motion involving general displacements, or else in both these ways. That magnetism pervades the whole solar domain can not be denied. That material bodies can act upon one another at a distance without a medium is not affirmed, and can not be affirmed with reason. The alternative just proposed can rationally be insisted upon, whatever may be the medium of magnetic effects. Therefore, the physicist who is constrained by any facts or considerations

known to him to conclude that there is no such thing in the universe as general currents or other general displacements of the medium, must accept the other alternative, that all the effects known to occur are due to vibratory or wave motions in the medium. Thus, for general reasons, as well as in view of the particular facts herein before set forth, a wave theory of universal magnetism and of gravitation is tenable.

But, though all this be granted, a greater problem of the universe remains unsolved. Why was there ever any motion of any kind? This is *The Ultimate "Why?"*. When no solar commotions agitated the ether, for the reason that matter had not yet been collected into masses to form solar orbs, why did it not continue in eternal quiet? Put in another way, the question is still more significant and difficult of solution: When agitation began, why did it continue in such a manner as to produce all the orderly results which now characterize the physical world? The inquiry is as old as philosophy. But the aspect of the problem changes continually as investigation proceeds and knowledge is advanced. To attack it fairly, not to say successfully, every essence known to be, or with reason believed to be, an active agent in the formation of the universe. should be con-

sidered both as to its being entitative, and as to its function in the general scheme.

Emmanuel Kant, the famous philosopher of Konigsburg, said, "Give me matter and I will explain the formation of a world; but give me matter only, and I can not explain the formation of a caterpillar." The English scientist, Thomas Huxley, in his article on biology in the British Encyclopedia (ed. of 1876, p. 679), says: "The properties of living matter distinguish it absolutely from all other kinds of things; and the present state of knowledge furnishes us with no link between the living and the not-living." Sir Oliver Lodge says in his little volume, "Life and Matter" (p. 133): "I perceive, not as a theory, but as a fact, that life is itself a guiding principle, a controlling agency; *i. e.,* that a live animal or plant can and does guide or influence the elements of organic nature."

Since LIFE is believed by many great thinkers to be "a guiding and controlling entity which interacts with our world according to laws," we may proceed without apology to consider its essence and its relation to physical phenomena in the universal scheme.

XI.

The Essence of Life.

What is life? The problem is one of the oldest in philosophy. Nobody should expect the answer to be more complete than that to the question, "What is hydrogen?" or more satisfactory than to an inquiry as to the essence of any of the material elements. We discriminate each from the others by pointing out those phenomena, or states, or appearances, which can not be accounted for without the presence and agency of the element being described. The biologist directs attention to life phenomena in the broad field of physio-chemical processes attending organic structures which are built up and maintained by life. The zoologists classify the various forms of animate nature that life nourishes and perpetuates. So also the botanist takes another limited view of life phenomena. The psychologists limit their researches to those higher functions of life, or functions of higher life, where sensibility, intellect, and volition are concerned. But none of these ever attempt a definition of life, for the reason that nobody pretends to know what it is.

The school of materialistic monists deny that life is an entitative essence, holding the mechanistic view, that all life phenomena are mere chemical reactions, and that death is the cessation of these chemical reactions, and does not result from the departure from a living organism of a distinct vital agent. Before proceeding to speak of what life does in the universal scheme, then, it is of the first importance to consider the evidence of its existence as a distinct reality, such in respect of actuality as oxygen or hydrogen.

Dr. Jacques Loeb, M.D., Ph.D., Sc.D., a member of the Rockefeller Institute for Medical Research, whose name means *lion,* may be justly regarded as "the lion of the tribe" of materialistic monists in the United States of America. For the past fifteen years at least he has scientifically tested the mechanistic conception of life, making experiments with certain echinoderms, at the Bay of Naples, at the Bay of San Francisco, and at New York, with the best of modern equipment; he has appeared by request before the leading monists of Europe to give account of his discoveries; and he has recently published a volume containing those lectures, addresses, and essays in which his most mature notions are set forth. Quotations from his book, published by the Chicago Uni-

versity Press, July, 1912, will fairly present the evidence of progress in discovery in this field of investigation by materialistic monists.

"It is the object of this paper," he says in beginning his address before the first International Congress of Monists at Hamburg, in 1911, "to discuss the questions whether our present knowledge gives us any hope that ultimately life—*i. e.,* the sum of all life phenomena—can be unequivocally explained in physio-chemical terms." In editing his volume of essays which now appears under the title, "The Mechanistic Conception of Life," he places the Hamburg address at the beginning, and makes the foregoing the introductory sentence of the work.

In further introductory remarks he limits the results of what he calls "modern biology" or "scientific biology" to two forms, explaining that "it is either possible to control a life phenomenon to such an extent that we can produce it at desire (as, *e. g.,* the contraction of an excised muscle); or we succeed in finding the numerical relation between the conditions of the experiment and the biological result (*e. g.,* Mendel's law of heredity)." (Mendel's law relates to "dominant" and "recessive" unit characteristics of parents and the uniform way in which they are transmitted.) Of course, it is readily

seen that the contraction of an excised muscle, and the transmission of black pigments from parents to offspring, for instance, necessarily involve physio-chemical processes. Admitting that this is so, if life is merely chemical reaction, it is no less so whether the life of a frog lingers in the muscle, or the life of a bean or of a guinea-pig as an entitative agent directs the transmission, or the life of the experimenter presides over the transaction. Defined in this sense, all the "results" of "scientific biology" may be attained and observed without touching the question as to whether "life is real."

Whether or not life is an entitative agent, all life phenomena under the observation of scientists necessarily take place within the gamut of physio-chemical processes, and in connection with them. Life structures are built up of material elements. In the process of building, these elements are disintegrated and combined again, whether wholly or partially as physio-chemical processes, always in harmony with physio-chemical laws. It has already been shown that at or below absolute zero chemical processes can not occur. There the ether itself is at rest, and heat has disappeared. Chemical action can not occur apart from that agitation of the ether which we perceive as heat. No form of animal or vegetable life (whether cell

or adult individual) is known to be able to overcome an absolute-zero environment and to continue zoo-chemical phenomena therein. So far as our knowledge goes, the lower limit of zoo-chemical processes is somewhere above the absolute zero. Further, it has been pointed out that chemical action can not take place where the ether agitation is sufficiently intense to result in dissociation of the material elements; and it is sufficient now to add that, for the reasons intimated, zoo-chemical phenomena can not take place in heat where chemical action is impossible. It follows, therefore, that life phenomena must be always associated with, and coincident with, physio-chemical processes where animal and vegetable forms are concerned.

This is like saying that architectural phenomena always occur where there are building materials, and that these must necessarily be erected with due regard to the law of gravity; but these statements do not prove gravity to be the architect. In animal building, life may be the architect, or the builder, operating with the aid of physio-chemical agents. Of course, there is the more profound problem as to whether there is a Life capable of controlling all physical conditions, even where chemical processes are impossible.

These remarks must suffice to indicate the

two important aspects of his undertaking, and to put the reader on the *qui vive;* and now Dr. Loeb is here permitted to state fully, in his own language, the genesis and the aims of his task:

"Scientific biology, defined in this sense, begins with the attempt made by Lavoisier and Laplace (1780) to show that the quantity of heat which is formed in the body of a warm-blooded animal is equal to that formed in a candle, provided that the quantities of carbon dioxide formed in both cases are identical. This was the first attempt to reduce a life phenomenon—namely, the formation of animal heat—completely to physio-chemical terms. What these two investigators began with primitive means has been completed by more recent investigators—Pettenkofer and Voit, Rubner, Zuntz and Atwater. The oxidation of a foodstuff always furnishes the same amount of heat, no matter whether it takes place in the living body or outside.

"These investigations left a gap. The substances which undergo oxidations in the animal body—starch, fat, and proteins—are substances which at ordinary temperatures are not easily oxidized. They require the temperature of the flame in order to undergo rapid oxidation through the oxygen of the air. This discrepancy between the oxidations in the living

body and those in the laboratory manifests itself also in other chemical processes; *e. g.,* digestion or hydrolytic reactions, which were at first found to occur outside the living body rapidly only under conditions incompatible with life. This discrepancy was done away with by physical chemists, who demonstrated that the same acceleration of chemical reaction which is brought about by a high temperature can also be accomplished at a low temperature with the aid of certain specific substances, the so-called catalyzers. This process is connected pre-eminently with the names of Berzelius and Wilhelm Oswald. The specific substances which accelerate the oxidations at body temperature sufficiently to allow the maintenance of life are the so-called ferments of oxidation.

"The work of Lavoisier and Laplace not only marks the beginning of scientific biology, it also touches the core of the problem of life; for it seems that oxidations form a part, if not the basis, of all life phenomena in higher organisms.

"By 'the riddle of life' not everybody will understand the same thing. We all, however, desire to know how life originates and what death is, since our ethics must be influenced to a large extent through the answer to this question. We are not yet able to give an answer

to the question as to how life originated on the earth. We know that every living being is able to transform foodstuffs into living matter; and we know that not only the compounds which are formed in the animal body can be produced artificially, but that chemical reactions which take place in living organisms can be repeated at the same rate and temperature in the laboratory. The gap in our knowledge which we feel most keenly is the fact that the chemical character of the catalyzers (the enzymes or ferments) is still unknown. Nothing indicates, however, at present that the artificial production of living matter is beyond the possibilities of science.

"This view does not stand in opposition to the idea of Arrhenius that germs of sufficiently small dimensions are driven by radiation-pressure through space; and that these germs, if they fall upon new cosmic bodies possessing water, salts, and oxygen, and the proper temperature, give rise to a new evolution of organisms. Biology will certainly retain this idea, but I believe that we must also follow out the other problem; namely, we must either succeed in producing living matter artificially, or we must find the reason why this is impossible."—*The Mechanistic Conception of Life,* pp. 4-6.

This fairly sets the problem and shows both its scope and its importance. The salient points

which relate to the present inquiry will now be considered so far as they bear upon it.

1. The "physical chemists," first and last, have found that the living body, with the aid of the so-called catalyzers (the enzymes or ferments of oxidation, which are produced exclusively by living bodies), accomplishes oxidations and hydrolytic reactions at lower temperatures than are required in the laboratory for accomplishing the same results. The physical chemists have had this fact before them for scientific inquiry for one hundred and thirty-two years, and now Dr. Loeb says: "The gap in our knowledge which we feel most keenly is the fact that the chemical character of the catalyzers (the enzymes or ferments) is still unknown." All this tends to show that mere physio-chemical processes are incapable of producing the catalyzers or enzymes or ferments of oxidation.

The unaccounted-for movements of Uranus, which deviated a little less than two minutes of arc from its computed path, suggested to the English astronomer Adams and to the French astronomer Leverrier, the presence and influence of another planet; and this open-mindedness of these observers of the open heavens led to the discovery of Neptune. It would require a volume to recount the times and the conditions in which different scientific investigators have

shrewdly and correctly inferred the existence of hitherto unknown agents from the inscrutable behavior of known elements under investigation. If the idea of life as an entitative agent were not already possessed, it is likely that some astute physical chemist would infer its existence as the only rational hypothesis on which to account for the facts which otherwise leave an impassable "gap in our knowledge."

2. The physical chemists "are not yet able to give an answer to the question as to how life originated on the earth"; but "the idea of Arrhenius that germs of sufficiently small dimensions are driven by radiation-pressure through space; and that these germs, if they fall upon new cosmic bodies possessing water, salts, and oxygen, and the proper temperature, give rise to a new evolution of organism," is held as reasonable, and "biology will certainly retain this idea," according to Dr. Loeb. The implied admissions are apparent and important.

Possibly life on this planet migrated from some other world! If it is merely a chemical reaction, why may it not have originated on the earth? To shift the supposed scene of its origin is to make no progress in unequivocally explaining it in physio-chemical terms. The idea of Arrhenius, in a slightly different form, was independently thought of, and was presented to

the British Royal Philosophical Society, by Lord Kelvin, in one of his presidential addresses, several years ago. This mode of disposing of the problem of life is like that of playing at hide-and-seek behind "catalyzers" and "enzymes." Yet, the idea has a certain value to those who hold it to be tenable.

Dr. Henry Charlton Bastian, a well-known English investigator, has recently reported experiments with inorganic matter that had been exposed to 135 degrees of heat, centigrade, in sealed culture tubes, in which bacilli and micrococci appeared subsequently. Dropping all questions as to the degrees of cold and heat which germs may successfully endure, if the idea of Arrhenius is tenable, and is certainly to be retained by biologists, it should be remembered that germs of sufficiently small dimensions to be driven through space by radiation-pressure, are small enough—being merely imaginary units—to invade Bastian's culture tubes, traversing the glass films as waves of the ether do, and thus to upset his claims! Of course, the claims of the French physicist Leduc will fall under this attack from above, as army entrenchments are to be destroyed by explosives dropped by bird-men from aeroplanes!

3. The physio-chemists find that it is "possible to control a life phenomenon to such an

extent that we can produce it at desire (as, *e. g.*, the contraction of an excised muscle)." The example might have been a more recent and a more surprising one; for Aloisio Galvani's wife observed the contraction of the muscles of a frog's leg by an electric current about one hundred and twenty-five years ago; but within the last decade certain organs of mammals, as hearts, kidneys, and ovaries, have been made to function for days and even weeks after the death of the bodies from which they were taken.

It will be seen later on that Dr. Loeb makes further admissions as to the impossibility with present knowledge to produce artificially any of these organs, or even a single life cell of which they consist. The fact, then, that certain functions of animal organs can be thus controlled, merely shows that life is capable of producing machines and parts of machines which, by the application of the stimulants that it employs, will continue to act after the builder thereof has withdrawn. A single very striking instance, out of the many available, may be given.

Professor William E. Castle, teacher of zoology in Harvard University, collaborating with Dr. John C. Phillips, by an operation deprived a sexually mature albino guinea-pig of her ovaries. Then, instead of the excised

ovaries, they introduced into her body, by grafting, the ovaries of a young black female guinea-pig which was not quite sexually mature. Later the grafted animal was mated with a male albino guinea-pig and bore offspring. The grafted ovaries, being properly nourished and stimulated, functioned as if they had remained in the living body that produced them, and they functioned *after their kind.* The offspring were black, like the female from which the organs were taken. In brief, this reproductive machine fully performed its function after the builder of it was dead. But this does not prove, or tend to prove, that the young black guinea-pig never had any real existence. Nor does it prove that life is a mere chemical reaction.

Dr. Castle bears his testimony unequivocally to the old and still prevalent belief that all life on the earth at present has come from pre-existing life. He says: "Every organism is derived from a pre-existing organism, so far as our present experience goes. It may not have been so always. Indeed, on the evolution theory, we must suppose that living matter originally arose from lifeless, inorganic matter. But if it did, this may have occurred, and probably did occur, under physical conditions quite different from those now existing. At the present time the most exhaustive researches fail

to reveal the occurrence of a spontaneous generation; that is, the origin of living beings other than from pre-existing living beings."

4. Dr. Loeb, for himself and all other scientists, accepts the physio-chemical task broadly and fairly. When he says, "We must either succeed in producing living matter artificially, or we must find the reason why this is impossible," he means "the sum of all life phenomena." His recent volume is an extended admission that, whatever may yet be possible, this has not been accomplished.

Notwithstanding his claim that the work of Lavoisier and Laplace marks the beginning of scientific biology, his own work shows that he has long been aware of the systematic investigations touching life phenomena in the matter of parentage and heredity beginning with Antonius von Leewenhook more than one hundred years before the experiments of these French scientists. In 1667, Leewenhook communicated to the Royal Society his discovery of the essential function of the paternal moving bodies in sperma, previously supposed to have no relation to fecundation. Then for three-quarters of a century the nature and function of the so-called spermatozoa were investigated experimentally by Parsons, Leddermuller, Swammerdam, Needham, Buffon, Daubenton,

Sir Everard Home, Spalanzani, Bonnet, Gleichen, Provost, Dumas, Barry, Wagner, Siebold, Muller, Kolliker, and others of less note. At last Kolliker showed conclusively that these active particles are indispensable spermatory constituents of the male parental body, which was reported in 1841.

It is an interesting fact, which may be mentioned incidentally to remind the reader of the attitude of the scientists with regard to the indispensability of dual parentage, that for nearly two thousand years the main point of attack on the doctrine of the divinity of Jesus Christ has been the denial of his "virgin birth," which if true is an exception to the otherwise invariable law of dual parentage. Nor is it of any scientific avail for Christian philosophers to meet this objection by pointing, with Dr. Joseph Cook, to the facts touching fission, self-fertilization, self-pollination, parthenogenesis, and agamogenesis; for neither of these modes of reproduction furnishes a real exception to the great universal law. The Christian philosopher must make out his case consistently. The Bible itself stands for this law; for in Genesis, at the close of the summary of living things created, there is the general statement that *"male and female created he them";* and unquestionably the application of

this statement to mankind is meant, if not to all other living things.

In the propagation of bacteria and micrococci, which occurs in fluids, fertilization may be transmitted through the element they inhabit, as with fishes. In self-pollination, though the plant-stock is an individual, the reproductive organs, commonly brought together in the flower, are male and female. The same is true substantially of hermaphroditic animals. But in neither of these cases are the surviving eggs wholly fertilized from the individual adult plant or animal producing them. In the cases of bees, ants, and aphids, for instance, when the whole cycle of reproduction is studied, it is found that "male and female created he them," and that dual parentage is indispensable.

In Dr. Loeb's conception everything essential to reproduction must be artificially produced in operative perfection by any one who claims to develop living matter from not-living matter. Therefore, one line of his experiments attempted to supply physio-chemically the elements due to the paternal ancestor. He succeeded in developing embryos from eggs not normally fertilized; but he failed to produce in even this way a normal adult. Also he attempted fertilization with carefully *killed* sperma of the same species as the eggs, and failed. Again he attempted

it with killed sperma of an allied species, and succeeded in developing eggs to the larva state. But no reproductive adult was produced. The same is true of all attempts at hybridization. According to Loeb's own test, "that a species is only able to live—or, to use Roux's expression, is only durable—if it is provided with the automatic mechanism for self-preservation and reproduction," all of his experiments to prove the mechanistic conception of life have given negative results.

He closes his recent volume with an essay reprinted from "Darwin and Modern Science" (1909), in which incidentally he sums up his constructive, destructive, and instructive failures, in the following three paragraphs at the end of this essay. They are quoted in full, to reveal fully their naive admissions:

"The discovery of DeVries, that new species may arise by mutation, and the wide if not universal applicability of Mendel's law of phenomena of heredity, as shown especially by Bateson and his pupils, must, for the time being, if not permanently, serve as a basis for theories of evolution. These discoveries place before the experimental biologist the definite task of producing mutations by physio-chemical means. It is true that certain authors claim to have succeeded in this, but the writer wishes to apologize

to these authors for his inability to convince himself of the validity of their claims at the present moment. He thinks that only continued breeding of these apparent mutants through several generations can afford convincing evidence that we are here dealing with mutants rather than with merely pathological variations.

"What was said in regard to the production of new species by physio-chemical means may be repeated with still more justification in regard to the second problem of transformation; namely, the making of living from inanimate matter. The purely morphological imitation of bacteria or cells which physicists have now and then proclaimed as artificially produced living beings, or the play on words by which, *e. g.,* the regeneration of broken crystals and the regeneration of lost limbs by a crustacean were declared to be identical, will not appeal to the biologist. We know that growth and development in animals and plants are determined by definite, although complicated, series of catenary chemical reactions, which result in synthesis of a *definite* compound, or group of compounds; namely, *nucleins.*

"The nucleins have the peculiarity of acting as ferments or enzymes for their own synthesis. Thus a given type of nucleus will continue to synthesize other nuclein of its own kind. This

determines the continuity of a species; since each species has, probably, its own specific nuclein or nuclear material. But it also shows us that whoever claims to have succeeded in making living matter from inanimate will have to prove that he has succeeded in producing nuclear material which acts as a ferment for its own synthesis and thus reproduces itself. Nobody has thus far succeeded in this, although nothing warrants us in taking it for granted that this task is beyond the power of science."

The capital admission is, of course, that neither a reproductive group of living cells, nor even a single cell having all the potentiality of the smallest unit of living matter, has yet been produced in the laboratory. The other admission, that the walls between the different species have thus far proved to be inviolable, is hardly less important. So much from Dr. Loeb.

The persistence of the several species in the presence of the physio-chemical products of other species, is one of the phenomena that tend to prove the entitative nature of life. A few instances may be given. "Certain Forminifera have not varied since the Silurian epoch. Unmoved witnesses of the innumerable revolutions that have upheaved our planet, the Lingulæ are to-day what they were at the remotest times of the Paleozoic era" (Henri Bergson).

Yet, the Lingulas live and deposit their eggs in the sands of the seashore in all parts of the world, where they are exposed to the sperma of allied species and of thousands of other species. The imprint of the fronds of ferns are found on stone-coal laminations which show the species of the Carboniferous age to be identical with yet living species growing in the vicinity of their ancient ancestors. The writer saw a toad liberated from the midst of a large mass of solid oolitic limestone near Spencer, Indiana, in 1871, and witnessed its restoration to normal activities at the close of its long period of hibernation, which may have been millions of years. It was in appearance identical with the toads living about the stone quarry at the time of its liberation. The capital fact is that its more fortunate kinstoads had remained inviolably steadfast in the family likeness.

Anah, a grandson of the Horite Seir, found mules in the wilderness of Horeb, while herding the asses of his father Zibeon, some time before the Book of Genesis was written. That was unquestionably over two thousand years ago, and the probabilities are that the incident occurred over three thousand years ago. Since then there have been millions of this remarkable hybrid; but not one of them has ever been known to possess the power of reproduction.

This is so instructive, it is remarkable that the scientists rarely make mention of it. Can this be because the mule furnishes an instance of "reaction" which gives even the "physical chemists" pause? It is enough.

There is nothing else which we know so completely as we know that life is entitative. All other knowledge comes to us mediately, and is received on the testimony of our senses. But it is given to each of us to recognize the existence of one life immediately; namely, his own life. For consciousness is a life phenomenon; and when one turns consciously to the idea of his own existence, and says, "I AM," his proposition lies beyond the realm of dispute. This laconic sentence expresses the sum of the direct, immediate, absolute knowledge possessed by any intelligent human being.

But within the realm of mediate or comparative knowledge there is an indisputable truth which alone is as convincing proof of the actuality of life as are all the proofs of the actuality of hydrogen, or of any one of the material elements. To make this apparent, the reader is reminded that every other essence known to us is inert. "However complex the protoplasmic molecules may be, its atoms are still nothing but matter, and must share its properties for good or evil, and among the rest inertia. Hence it

can not change its state of motion nor rest without the influence of some force from without. True spontaneity of movement is, therefore, just as impossible to it as to what we call dead matter. . . . So we are compelled to admit the existence of an exciting cause in the form of some force from without to give the initial impulse in all vital action" (Dr. Drysdale). Strictly "automatic" action can not reasonably be attributed to any aggregation of atoms, molecules, or bodies of inanimate matter, as all philosophers admit.

Dr. Henri Bergson, professor at the College de France, and a recent writer of great renown, makes this admission in the phraseology of his own philosophy: "If life realizes a plan, it ought to manifest a greater harmony the further it advances, just as the house shows better and better the idea of the architect as stone is set upon stone. If, on the contrary, the unity of life is to be found solely in the impetus that pushes it along the road of time, the harmony is not in front, but behind. The unity is derived from a *vis a tergo*: it is given at the start as an impulsion, not placed at the end as an attraction." Again: "Suppose, as we suggested in the preceding chapter, that at the root of life there is an effort to engraft on to the necessity of physical forces the largest possible amount

of *indetermination*. This effort can not result in the creation of energy. . . . All that the effort can do, then, is to make the best of the pre-existing energy which it finds at its disposal." More briefly in another connection: "Life is, more than anything else, a tendency to act on inert matter" (*Creative Evolution*).

Life, unlike any other essence known to us, can initiate motion. This every one knows who can lift his hand or move any muscle of his body. Here, then, is something differential, a something characteristic of life, but never found inherent in any other essence or element. This is the convincing proof from our comparative knowledge that life is an entitative reality. It is not new; but it is one of the older conceptions which can not be shaken. Even Haeckel's solution of "The Riddle of the Universe," one of the most notable attempts to show that life is a development from ponderable matter, confirms rather than disproves this conception. His ideas are unique, but instructive.

Haeckel explains what he calls the "Law of Substance" to be "the eternal persistence of matter and force." He makes the "conservation of energy" plus the "conservation of substance," the all-inclusive components of the Cosmos. According to him, the universe is eternal, infinite, and illimitable. Its substance fills all space,

and is in eternal motion. This motion runs on through infinite time as an unbroken development, with periodic changes from life to death. The separate atoms "are credited with sensation and inclination (or will-movement of the simplest form), with soul, in a certain sense—in harmony with the old theory of Empedocles of the 'loves and hatreds of the elements.' Moreover, these 'atoms with souls' do not float in empty space, but in the continuous, extremely attenuated, intermediate substance, which represents the uncondensed portion of the primitive matter" (p. 77). "The two fundamental forms of substance, ponderable matter and the ether, are not dead and only moved by extrensic force, but they are endowed with sensation and will (though, naturally, of the lowest grade); they experience an inclination for condensation, a dislike of strain; they strive after the one and struggle against the other" (p. 78). "Every shade of inclination, from complete indifference to the fiercest passion, is exemplified in the chemical relation of the various elements towards each other" (p. 79).

Pursuant to these statements he reaches his conclusion in the following: "On those phenomena we base our conviction that even the atom is not without a rudimentary form of sensation and will, or, as it is better expressed, of feeling

(*æsthesis*) and inclination (*tropesis*); that is, a universal *soul* of the simplest character" (p. 80).

It is hardly necessary to say that all this supports the contention that all life is derived from antecedent life, and that life is one of the eternal, fundamental, indestructible, actual elements of the universe.

None of the evolution theories advance anything more rational than Haeckel's notions of the genesis of life. Neither Darwinism nor Darwinianism—the one being Charles Darwin's *ism* and the other being a blend of this with the several *isms* of his disciples—attempts an account of the origin of life. The evolution theory under these names begins with protoplasm, a compound the indispensable elements of which are oxygen, carbon, nitrogen, and hydrogen, and the essential characteristic of which is life. It undertakes merely to account for the origin of the species. The Darwinian is free to follow Haeckel, or to leave the topic alone, or to follow another leader, or to propound a new theory, as it may suit his inclinations.

Protoplasm was first noticed by the scientist Rosel in 1755, but was so named much later. Felix Dujardin, a French naturalist, described it as "a sort of slime" and characterized it as

"a primary animal substance" in 1835. Hugo von Mohl used the term *protoplasma* with reference to it in 1846, though the name by which it was known then was *sarcose,* which conveys the idea of flesh. He, having discovered the same substance in vegetable cells, must have felt the need of a better name. In 1850, Ferdinand Julius Cohn identified the two as one, and called it protoplasm. These contemporaries of Mr. Darwin thus laid the foundation for the theory which he elaborated. In his *first vital plasm* life was already at hand and at work. There was neither the need nor an attempt to account for it.

Bergson, in his "Creative Evolution," outdoes all this. He is a difficult writer to quote from, if one would do justice to his views, because he proceeds somewhat in the manner of those insects that appropriate nectar from flowers. They flit hither and thither, attracted by every whiff bearing odors and by every glint of color in the landscape, visiting all varieties of plants, sniffing at the fragrance of one and drinking deep of the distilled sweetness of another, and then they go their ways laden with precious products whose physio-chemical nature they do not understand; and of these they compound the delightful and nourishing blend which we call honey, a commodity that is manufac-

tured in utter disregard of "the pure food law." So Bergson; yet, he may occasionally be caught with single bits of "sweetness" in very clear rays of light, which may be found on separate leaves. He says: "At a certain moment, in certain points of space, a visible current has taken rise; this current of life, traversing the bodies it has organized one after another, passing from generation to generation, has become divided among species and distributed amongst individuals without losing anything of its force, rather intensifying in proportion to its advance" (p. 26). "Of phenomena in the simplest forms of life, it is hard to say whether they are already vital. Life had to enter thus into the habits of inert matter, in order to draw it little by little, magnetized, as it were, to another track" (p. 99). Elsewhere he speaks of "the primordial tendency of life," of its "original impetus," of its "initial movement," and of its "struggles."

As to this genesis, which makes life "a visible current" traversing material organisms, all intelligent persons know that a visible current never arises fortuitously. For it, as this philosopher in a passage already quoted admits, there must be a *vis a tergo*. Besides, the reader knows that a *current* is not an *entitative* thing, but merely a condition of the substance in which

it is perceived. Although he says, "In reality, life is no more made of physio-chemical elements than a curve is composed of straight lines," yet, in the foregoing description of life as a current traversing matter, he appears to go over to the mechanists neck and crop. In brief, this philosophy presents to us the inadequate conception of a fortuitous current traversing inert matter and endeavoring to enter into its habits, by the force of an "original impetus," before inert matter could have had any habits, in order to draw it out of one track into another! The same objection lies against this conception of the origin of life phenomena as against any and all claims of perpetual-motion ideas. But it involves another conception which is open to an equally insurmountable objection.

"This current of life," after having arisen fortuitously, is said to have proceeded "without losing anything of its force, rather intensifying in proportion to its advance." The implied comparison is to the acceleration of momentum with which a stream of fluid descends an inclined surface. But the conditions are different in an important particular. Back of the flowing current in the stream is the force of the etheric pulses to which gravitation is due. But the "current of life" must resist these, must resist

the action of gravity tending to bring every atom on the earth to rest, and must organize the bodies it traverses in spite of all adverse tendencies in the material world. Therefore, to perpetuate its phenomena, and to extend its operations, there would have to be new pushes added perpetually to the original impetus. This would make all life phenomena depend on fortuitous pushes *a tergo*. To account for these would be more difficult than to account for life conceived of as a real essence.

The fact of dual parentage, which is exemplified in all forms of life on the earth, was mentioned in a preceding paragraph by way of introducing Dr. Loeb's experiments. Before leaving the discussion of mechanistic conceptions and evolution theories, it is worth while to point out the difficult problem which this fact sets for the mechanistic monist and for the Darwinian evolutionist. "Give us a first pair," says Mark Hopkins, "and we have no difficulty; without that, it seems to me we must suppose processes for which facts furnish no support, and the present order of Nature no analogy."

Here is another need for fortuitous happenings. It is interesting to see how this dogma of one school of evolutionists appears to the champion of another school. Professor Bergson says, by way of showing up the difficulties of the prob-

lem: "The Darwinian idea of adaptation by automatic elimination of the unadapted is a simple and clear idea. But, just because it attributes to the outer cause which controls evolution a mere negative influence, it has great difficulty in accounting for the progressive and, so to say, rectilinear development of complex apparatus such as we are about to examine. How much greater will be this difficulty in the case of the similar structure of two extremely complex organs on two entirely different lines of evolution! An accidental variation, however minute, implies the working of a great number of small physical and chemical causes. An accumulation of accidental variations, such as would be necessary to produce a complex structure, requires therefore the occurrence of an almost infinite number of infinitesimal causes. Why should these causes, entirely accidental, recur the same, and in the same order, at different points of space and time? No one will hold that this is the case, and the Darwinian himself will probably merely maintain that identical effects may arise from different causes, that more than one road leads to the same spot. But let us not be fooled by a metaphor" (*Crea. Evo.*, p. 56).

There is no antecedent probability against the conclusion that life is as real an essence as

oxygen; science reveals no fact which stands in the way of this conclusion; philosophy affords no rational solution of the problems of life on any other hypothesis; the conclusion is in accord with the averment of every one's consciousness; and therefore we may confidently assert that "life is real," and is, whether temporal or eternal, one of the entitative agents of natural phenomena.

XII.

Functions of Terrestrial Life.

The unassailable barriers between the species, and the fundamental difference between animals and plants, suggest a study of the functions of terrestrial life.

When we embrace in the one word *life* the idea of all vital phenomena, we assume that there is a something which is common to all the species in every living thing; but when we trace the limits of variability set about the several species, we perceive that each species has a power and exercises a function impossible to any other. It will be helpful, then, to set down first those things which are characteristic of every terrestrial form having life. The summary can be only approximately complete.

1. In every manifestation, life comes from antecedent life. Throughout the voluminous speculations of scientific biologists, this is either frankly admitted or tacitly implied. Huxley, in his article "Biology" in the British Encyclopedia (p. 689, ed. of 1876), asserts that "at the present moment there is not a shadow of trustworthy direct evidence that abiogenesis does

take place, or has taken place within the period during which the existence of the globe is recorded." By "abiogenesis" he means spontaneous generation. It has already been mentioned that such recent writers as Loeb and Castle agree with this view. The hypothesis of life's migration from some other world or worlds is a most significant admission of the fact that *life comes from life.*

2. Every individual form begins the structure of its separate integument as the result of the union of male and female parental cells, and possesses the power to reproduce parental cells after its own kind. To quote Dr. Loeb again: "The nucleins have the peculiarity of acting as ferments or enzymes for their own synthesis. Thus a given type of nucleus will continue to synthesize other nucleins of its own kind. This determines the continuity of a species." Reproductive cells are not merely peculiar to the species by which they are formed, but are of the sex of the individual in whose organism they are constructed. Both kinds of parental cells contain and transmit antecedent parental strains or traits; but the maternal parent furnishes the greater amount of cells for preliminary nourishment.

3. Life in every individual form transmutes the material elements, of which it makes its

integument, into cells peculiar to its own species, whether they be organic or inorganic when received and appropriated. Microscopic investigations of late have furnished many interesting confirmations of this statement. The cells of the different species are as characteristic in morphology as the molecules of the material elements are reasonably believed to be upon the evidence furnished by chemistry. But the cells, or units of which living organisms are built up, always take, or tend to take, spheroidal form. Every special life has power to form different cells which are adapted to the formation of the several organs that combine to constitute the individual. The power to form an eye is as completely possessed by many of the inferior species as by the highest, for instance.

4. Life in every species constructs and maintains the forms peculiar to it automatically through the periods of infancy, youth, and puberty, thus performing the functions of growth and reproduction. This function is not one of mere increment, like the building up of a sand-dune; for, though the dune is one of Nature's aggregations of organic particles, the sand particles are organized as crystals and are indiscriminately mixed, whereas the aggregated particles in the living matter are cellular and are woven into tissues, organs, and operative

machines. In the main, animals and plants are alike in these respects.

5. Every life dominates something, and operates to extend its powers. Characteristically, though not exclusively, life in the vegetable kingdom reigns in the material world. All plants have the power to convert inorganic matter—so-called—into organic, or, properly speaking, into cellular, matter. Every life has power to disintegrate and to re-form material elements in ways for which neither physics nor chemistry can account. The physio-chemists are able to say that so and so is accomplished by catalyzers, enzymes, or ferments; but they are obliged to add that they are wholly ignorant of the chemical character of these life-formed specific substances. Animals not only appropriate plants, but several species of animals besides mankind cultivate them with a view to their use as foodstuffs. Finally, mankind, ranking as far above all other animals as others rank above plants, dominates all other living things on the planet, as well as the material elements of which the others and humanity are formed.

In all species of both kingdoms vital dominance is characteristic of cells and reproductive units (gamates and zygotes) as well as of individuals and orders. Mendel's experiments revealed the law of cellular dominance which

bears his name; and though his experiments dealt with peas and other plants, later investigations show that his discovery can be verified by experiments with any species of the animal kingdom. Dominance in the sense of immunity from interference or intervention is characteristic of every cell of every species; for it is unquestionable (1) that reproductive cells are composed of elements from all parts of the organisms, strains from all being hereditary, and (2) that the cells of each species are immune from mutation by the cells of any other species. In the same sense sex cells are dominant; they do not brook intervention, or encroachment of the one upon the other's sphere. Both survive in spite of any and all physiochemical processes. Of course, what is here said of cells must be true of gamates and zygotes, for the reason that they are but groups of cells. Again, of course, by species is here meant the kinds of animals and plants which will interbreed with productive offsprings, and what Dr. Loeb calls "merely pathological variations," is not meant.

6. Every living thing normally renders some compensative service in the general scheme of terrestrial life. No species lives for itself alone. No species lives without the aid of other species. Bacteria and micrococci assail and disintegrate

organic substances and render their elements available for rebuilding into new forms. They distill toxins and produce ferments of service to other creatures. Insects distribute the pollen of innumerable kinds of flowers. Birds scatter and replant the essential seeds of plants in return for the pericarp of berries and of pomes on which they feed. The species of the vegetable kingdom furnish food, shelter, and building materials for the species of the animal kingdom which are absolutely indispensable to the latter. In like manner the animal species afford one another food and service upon which their lives depend. Whether voluntary or involuntary, this general-service function is rendered by every form of life, and is indispensable to the perpetuity of the several species and orders upon the earth.

Now we may descend from the broad truth, that every living thing is of service to some other living thing, to the idea that each is of some special service. Yet, it is well worth while to keep in mind that there are no abrupt transitions in nature, neither from one form to another, nor from one function to another. Though the chasm between animals and plants seems very wide, if the higher species in each be compared, the distinction is not quite easily made out when certain of the simplest of the

inferior species of both are compared. Characteristics are overlapping, as in case of sponges, polyps, and polyzoa, which are rooted to their abodes as are plants. Again, some plants seem to possess sensibility and to exercise volition. So, as no living thing can be said to have a completely unique form, no feature of which is duplicated by any other, none can be found having a function that is performed by it exclusively. In brief, both morphological structures and general-service functions are overlapping throughout the whole field of vital operations. Yet, throughout, distinct functions are as readily recognizable as are varieties in material conformation.

Few persons, perhaps, have set before themselves the large and important part taken by what are known as the inferior forms of life in the structure of our globe. Much of the earth's substantial strata is due to mollusks, crustacia, protozoa, and to vegetable growths. The limestone strata, including much marble, are composed of shells and calcareous aggregations due to animal life. All coral formations, of course, are included in this enumeration of life products in the earth's crust. Then all the coal strata are vegetable products, if the prevailing conception of coal formation is correct; and the sundry vegetable substances derived from coal are con-

firmations of the prevailing view. The way in which the deposits were made may not yet be correctly understood; but there can be no doubt of the fact that this vast portion of the earth's crust is due to plant life. Its stored-up energy is frequently referred to as solar energy; but with equal truth it may be thought of as vital energy conserved by petrification, and reserved for general service later on. The fertile soils covering the lifeless rock-structure, which are so necessary to the perpetuation of life on the earth, consist very largely of decayed leaves and stems of plants and of animal matter; and the very atmosphere is loaded with exhalations from both plants and animals. It is interesting to try to form a rational conception of what the earth would now be without the results of life's activities during its upbuilding. But it is still more interesting and instructive to meditate upon the evidences that life constructs planets as certainly as it builds trees and animal bodies. Not in the same way, or in the same form or fashion, of course; but life is "the master builder" in our world at least.

The construction of the framework of a world is a great and important task, great in its execution and important in all the results to follow from it. It is remarkable that such a stupendous task was assigned to creatures so

low in the scale of the species, and to individuals comparatively so impotent. Yet, they are admirably adapted to the task, as is shown by their accomplishments. We talk of the importance of the life-work of noted individuals, and also of generations, of our race; but can we point to the accomplishments of any man or generation of men that rank in magnitude, or in importance, with the work of these so-called inferior creatures? If they are to be honored with the full meed of credit, we may well revise our notions of our comparative importance in the vital undertakings on this planet. Or, if gigantic material structures are the best proofs of greatness, we must consent to rank below the mollusks and the zoophites.

In any correct scientific classification, the *principii divisionis* must be characteristics which belong to all the things differentiated and classified, and the differences justifying the classification in every case must relate to these leading principles. Any universal characteristic may be employed as the principle of division, but the largest and most important groups should be differentiated with regard to the most important universal likeness. But dominance is the chief characteristic of life; and, therefore, the several major divisions of living things on the earth must be made with reference to radical

differences touching their dominancy. Accordingly, terrestrial life is scientifically viewed in three distinctly marked aspects of the dominance of vitalized forms; and every living thing falls naturally into one of three divisions; namely, *plant, brute,* and *human.*

As has been seen, living things are differentiated from all other things by inherent dominancy, whereas all other things are characterized by inertia. Even the ether, which is more mercurial than mercury itself and more antitypous than electricity, is so inert that a wave in it propagated by the sun requires eight minutes to traverse the space intervening between the sun and the earth. Nothing else is better known in physics than that etheric commotions begin to abate so soon as the causes of perturbation are withdrawn, and that they tend to complete cessation at the absolute zero. Mere material things move only by extraneous forces. Living things move by the inherent energy of life which overcomes inertia. Vital dominance, then, has relation always to motion.

1. Plant life is dominant in physio-chemical motion. "In all upbuilding by life there is first, not only a selection of material, but a preparation of it, and then a placing of it where it is needed. Hence the movement of the material is from within outward, which is never the

case under any lower force, and this movement is by a force which preserves the identity of the being while its materials are changed. We have, then, as discriminating the organic from the inorganic force, first, the preparation of the material; second, its movement from within outward, or to the point where it is needed. This is the beginning of a reverse movement, of a new order of things in which the process is not by aggregation or evolution or development, but by growth; and, third, there is identity of the being with the change of the material" (Mark Hopkins). In all this, physio-chemical motion is controlled and directed by the dominant essence, life.

But here the dominancy of life in the vegetable kingdom finds its limit. It acts against gravity in lifting all the ponderous materials of the forests; it directs osmotic pressures in the formation of stems, branches, leaves, flowers, and fruits; and it dominates physio-chemical actions in the construction of cells, and in the compounding of toxins, flavors, and odors. It directs the growth of stems upward, of roots downward, of branches outward, and of leaves away from neighboring leaves. In clinging vines it avails of electric charges to reach objects of support, in which it appears to reach out along "lines of magnetic force"; so it

avails of etheric heat and light commotion, in which it seems to reach out toward the sun or source of this aid; and in twining vines it directs the course of growth around the objects of support, with a suggestion of even higher elements of dominancy. In so-called sensitive plants, and so-called insectivorous plants, there are appearances of higher life phenomena; but, when fully understood, these motions exhibit neither sensibility nor purpose. Voluntary motion is lacking in the vegetable world. Here dominion is limited to the physio-chemical sphere.

2. Brute life dominates in the same sense as plant life, only to a less extent; and, besides, it dominates in another sense. Oxidation, hydrolytic processes, and other physio-chemical actions, are controlled in the growth and reproduction of animals. But in the general scheme the vegetable world receives nourishment directly from inorganic matter, as commonly defined, while animals receive nourishment from vegetable and other-animal matter. To acquire organic matter as nourishment, three things not possessed by plants are required; namely, sensation, purpose, and voluntary motion, to make the new order of domination effectual. Sight, smell, and taste enable the finding of suitable nourishment; voluntary motion enables the tak-

ing of it in all the ways and by all the means peculiar to this mode of domination. In all of it the lower kingdom is subservient.

Attention has already been directed to the fact that transitions are never abrupt, and that apparent exceptions are to be found along all border-lines. Plants prosper in loam, where organic matter abounds. Their work is made easier by the previous work of plant life. But, only in the sense that antecedent life must have formed the parent organisms, plant life is not absolutely dependent on organic material for subsistence, whereas animal life is so dependent; and plants do not go forth and take or capture their food, whereas animals do acquire their sustenance by this mode of domination over inferior orders.

The special characteristics of animals have a definite relation to dominancy. They are armed against foes. They are panoplied for defense. They are equipped for flight. They are provided with prehensile organs for the taking of food, and with organs for its trituration, digestion, and assimilation. Every feature and every trait bears a relation to the survival of the individual and of the species in a terrestrial environment; and in this kingdom there are abundant evidences of parental care in some species, and even of a larger

interest, a care for the welfare of the species. At least, any gregarious animals will act in defense of the group to which they belong.

The preparation of nests by birds, and the feeding and care for their young till able to fly and to provide for themselves; the mother-love of mammals during the period of the infancy of their offspring; the co-operative home-making of certain insects; and the tribal interests above mentioned—touch the limits of brute concern about kindred and posterity. The laying of their eggs by certain insects on leaves and fruits and barks of plants, to insure their young food for a brief period after the hatching, compares favorably with the habits of those vertebrate ovipera that deposit their eggs where they may be hatched by the warmth of the sun; but in neither case is further thought taken or other provision made for posterity. Dens are selected, burrows are dug, and tenements are constructed; but no improvement in home-building has ever been shown by any species of this order in the memory of mankind, nor does any evidence of such improvement appear in any prehistoric records of their life upon the earth. As parasites they appropriate the abodes and bodies of other species and live at the expense of their hosts; they influence other organisms by irritation, by producing

disease, and by furnishing occasion for remedial measures; but in no case do they direct orderly action by the species rendered subservient, unless it be in the case of certain ants (*exceptio probat regulam*); nor do they ever improve, or seek to improve, the creatures they lay under tribute. Some insects and a few vertebrates are credited with a low form of reasoning, shown in the use of means to ends; but no brute has ever made or used a tool, or invented and employed a useful device of any kind for any purpose. Throughout the entire kingdom there is a characteristic lack of self-improvement.

The brute reign is within a limited dominion, the only possible extension of their powers depending upon the increase of their numbers, and their consequent wider encroachments upon the spheres of neighbors. The beneficial services which they render in the general scheme of life are involuntary, and are, for the most part, unconsciously rendered. Thus, in every conceivable aspect of it, we are dealing here with a limited dominion.

3. The characteristic dominion of humanity is of a different and a higher order. The human body is capable of the dominancy exercised by plants, and also of that characteristic of brutes. In a state of coma it may be said to merely vegetate. At all times the mere physio-chem-

ical processes directed by brute and by human life are carried on involuntarily and unconsciously, as in plants. In abnormal persons and in degenerates the brute characteristics may predominate, the superior dominancy being little in evidence. Unfortunately, the evidence of brutishness in men is too abundant and too well known to require proof or extended mention here. But the facts, that it is abhorrent to the better classes of mankind, and that mere animalism wherever manifested is considered a sign of degradation, show that brute traits are not differential characteristics of human beings as humanity. The inferior conscious dominancy in the human kingdom is exercised under conscious restraints, at best. At the worst, then, the tokens of perversion or of degeneracy are shown.

(1) The dominion of human life is far and away wider than that of plant and of brute life. Besides the exercise of the same powers possessed by them, mankind dominates them; and besides dominion over them, all the material elements are laid under tribute for the accomplishment of human plans and purposes. The waters, the winds, electricity, and the ether, as well as all the metals, are made subservient in ways that are inconceivable by any brute. Though the forces of these elements exceed the

complete control of mankind, the measure of control already attained is infinitely beyond the conception of any of the brute creation. Herein brute life and human life can be compared only by their immeasurable differences.

(2) Man controls throughout his whole realm with reference to remote results for the welfare of himself, his generation, and posterity. He is capable of planning for the accomplishment of benevolent results to be attained after his death, the benefits of which are to accrue to the whole human family. This wide scope of interest in his kind, and aims so far-reaching, are beyond the powers of any brute. The difference here also amounts to a contrast between higher and inferior powers.

(3) Humanity reigns with justice, equity, and mercy. In justice, vice is restrained and crime is punished. In equity, exchange of values and commercial intercourse are established. In commiseration, the weak, the defective, and the afflicted of humanity are aided in a multitude of ways unthinkable among brutes. Indeed, where the limitations of the inferior order are discovered as regards all such things, the superior traits of humanity begin to appear; and the differences always amount to contrasts. In precisely what brutes are incapable of attempting, humanity invariably excels.

(4) In his dominance over the lower orders, man purposely undertakes and accomplishes the orderly direction of all the activities of the species under him; and he effects their improvement in health and special efficiency, tasks, as has been seen, that are never even dreamed of by any class of brutes. Nor is his care for them wholly selfish; for, in the most enlightened communities, out of mere pity, cruelties to them are prohibited.

(5) The dominion of humanity is a rapidly increasing dominion. More and more the inert elements are being mastered and made subservient. More and more the animal kingdom, especially the smaller and the minute members of it, are being brought under control. More and more all forms in the vegetable world are being studied, and their lives are being so directed as to make them less destructive and more commercially useful. It is not alone in the field of medical research, but also in the field of agriculture and horticulture, that this sort of dominancy is now being extended by leaps and bounds. In all directions in which the activities of mankind are requiring and pushing researches along the outposts of present knowledge, the dominion of humanity is being increased. Herein the most convincing proofs are to be found of the truth that humanity is a

distinct and superior order of terrestrial life; and especially that its dominancy is characteristically of a superior kind. That of plants is intra-dominancy; that of brutes is extra-dominancy; but that of humanity is super-dominancy as regards terrestrial life.

It is difficult, but worth while, to get an adequate conception of the vastness of the gap between humanity and the creatures in the order next below. The dog, the horse, the elephant, and the seal are amongst the most intelligent of the brutes. Does any one suppose that either of them could be made to know that the three angles of every triangle, such as he is familiar with as a corner in a room he has occupied, must be equal to two right angles? (Hopkins.) Would it be possible to convey to any one of them an apprehension of the ether of space? To take an instance of a widely different sort, witness the way of a bacteriologist with his "cultures." Here the being of the superior life provides and arranges in every detail the environment of the inferior; yet, the inferior is not even aware of his existence; nor would it be possible by any means to impart to a germ the remotest idea of the greater life, or of its organism as a manifestation of life. It knows nothing of the care being taken of it, and nothing of the interest being felt in the

peculiarities of its structure and the nature of its functions; for, naturally, bacteria are agnostic! The ultra-telescopic regions of the universe are not so far beyond the ken of the astronomer, as the heating apparatus of the laboratory is beyond the apprehension of the colony in the culture tube! Yet, the presiding genius in the laboratory is capable of constructing incomparably vaster and greater things than the buildings about him. The case may appear extreme, but it is a strictly real one.

But the superiority, the control, and the improvements due to human life are conditioned and have their limits also. All human advancement comes of the superiority of the human mind, and is a step-by-step progress in which each step depends upon the advance made in the previous step. But human capacity has not improved within historic times. Neither in the morphology of the body nor in the characteristic powers of the human species has there been any improvement. No find of so-called prehistoric men has brought to our knowledge a morphological structure that is at once unquestionably human and undoubtedly that of a creature of inferior capabilities. The constellations of the zodiac received their demarcations and names so long ago that history gives us no account of the primitive astronomers who

named them. Over a century before the Christian era Hipparchus, a Greek mathematician and astronomer, discovered that the equinoctial points do not hold the same position in the heavens, but have a slow westward motion at the rate of about one degree in a little more than seventy-one and a half years, and that they will complete a cycle in the heavens in about 25,800 years. He called this retrograde motion "the precession of the equinoxes," and it is still so called by astronomers. The discovery of copper and iron by Tubal-Cain, a grandson of Adam, and the manufacture of musical instruments by his brother Jubal, show the same capacities for discovery and invention in those primitive men as the gifts which made Sir Humphrey Davy and Beethoven famous. In a zoological aspect of it there has been no improvement or radical change in the human species of which we have any knowledge.

The superior control and extension of this control by humanity, being wholly due to immutable mental characteristics, gives no promise of the development from our own of a superhuman species, either through the attainments of science and invention or through eugenics. All that can be philosophically hoped for is, the complete development of the best that is in mankind—that has always been in mankind—

and the attainment of all that can be accomplished by the characteristic capacities of the race. Eugenics can do no more than to unite in individual men and women all the dominant human characteristics. Such men and women will not be superhuman. They will merely be humanity at its best. This best humanity will exercise the highest possible vital dominancy within the capacities of terrestrial life.

It has been said in a previous paragraph that humanity undertakes and accomplishes the improvement of the inferior species. It is worth while to note that there are limits to this improvement, and to point out the conditions of the limitation. Bacteriologists, entomologists, and stock-breeders, gardeners, fruit-growers, and farmers, all are engaged in efforts to improve the several species with which they deal. All who proceed intelligently proceed according to what is now known as "Mendel's Law." This may be appropriately called the law of dominant characteristics. To make this evident a few Mendelian facts may be given. His discoveries, as has been intimated, are of great importance in several aspects of them.

Mendel took a certain number of peas of differentiated characteristics, and observed the hereditary results separately for each characteristic. He crossed tall peas with dwarfs in

a series of experiments in which he obtained 1,064 plants, of which 787 were tall and 277 were dwarfs. The tendency to attain to normal proportions showed dominance, the tall offspring being about three to one of the dwarfs. He made a similar test with yellow and green colors, and found that the yellows predominated in the same proportion. He made like tests with peas of two different characteristics, and found the two dominant characteristics uniting in the larger group of offspring in the same proportion. Since his day the like tests have been made in a greater variety of ways, with both animals and plants, than were made by Mendel, and his "law" has been verified and its marvels further revealed. It is now recognized as the fundamental principle of all the improvements here under consideration, including eugenics, or the physical improvement of the human race. Not only is it true that "the hairs of your heads are numbered," but also are the cells of which the entire body is built up.

Now, the capital fact is, that any improvement the human species can make in any other species must be made in co-operation with the inherent dominancy characteristic of the inferior species. Besides, it will always find its limits when the sum of the species' capabilities is united in two matchable individuals of the

same species possessing the power of reproduction. Here humanity again is limited by nature's immutable laws.

This leads by a proper transition to the consideration of the limits of human dominance as the highest order of life on the earth. Man can not change the inherent characteristics of any species. He can change the channels of rivers, but he can not alter the course of ocean currents. He can ride upon the winds, but he can not direct the going of the clouds which they carry. He can navigate the ocean, but he can not set a limit to its majestic waves. He can neither alter the seasons, nor check the revolutions of the globe. Thus there are motions in and of the physical world which so far transcend human capacity as to put them beyond any present expectation of even human intervention.

Yet, for all this, man is doing some feats which are strikingly analogous to these things that are acknowledged to be impossible to humanity. The going of ocean steamers, on exact schedule time, regularly and perennially, between distant ports on the continents, against the resistance of the elements through which they float, and by applied forces different from the inherent energy of life which imparts motion to living things, presents an instance of

motion for which human life is accountable, that is analogous to the movements of the planets through the ether of space. For these modern ships are literally inhabited islands to which men have assigned oceanic orbits. The airships hint at regular sidereal orbits for such floating islands! The hint is a very broad one, for it not only brings to mind the multiplicity and the vastness of the movements of ponderable objects on the earth, for which human life is accountable; but it directs attention to another mode of dominancy not hitherto considered, that is even more indicative of human superiority than anything mentioned heretofore. For, at the root of it, this extension of the dominion of life involves physical control at a distance through the directed energies of the intangible essences of the universe. Its entire significance is not instantly obvious, but a little reflection will bring its importance to view.

The power of physical control at a distance through the agency of electricity and the ether of space marks the highest present attainment of terrestrial life. With the telescope we see objects which are immeasurably distant in the ether, but we acquire thus no control. In telegraphy we write at great distances through the agency of electricity, exercising distant control over ponderable matter. The so-called wireless

telegraphy involves control of ponderable matter with nothing intervening that is available for moving the matter except the ether. The operator causes the distant matter to respond to his impulses with such certainty as to make this a reliable means of instant communication of thought across thousands of miles of intervening space. Through this same agency experimental boats have been guided in sundry maneuvers, thus affording a distinct instance of the distant control of ponderable matter. All this is telepotence, and humanity has become telepotent in such a manner as to suggest the somewhat startling thought that only a slight extension of this power would place even worlds under human control.

To sum up, it is evident, (1) that life is a real essence, and that cellular organisms on the earth are all due to its agency; (2) that it has power to control, in certain senses and within certain limits, every known element and essence composing the Cosmos; (3) that the highest order of life on the earth possesses all the capabilities of the inferior orders, except the power of hereditary reproduction that is limited in each species, and the order next lower has all the capabilities of the lowest, with the same exception; (4) that life in the two inferior orders has been for countless ages constructively

active and efficient in the formation of our planet; (5) that certain species of the lowest order exhibit capabilities approaching those of the next order above it, certain species of the second order in turn show capabilities resembling those of the highest, and the highest order possessing zoo-dynamic capabilities which suggest a rational hypothesis upon which to account for the orderly motions of the planetary bodies of the universe; (6) that terrestrial life has a definite relation to motion; and that life is the only agent known to possess the inherent power to initiate motion.

Life's hieroglyphics, indelibly written in the species and orders on the earth, properly deciphered, prove to be a parable of the kingdom of the heavens.

XIII.

Higher Possibilities of Life.

There are many aspects of the problem of life on other planets. The fact that the Solar System is to the universe as a little swarm of gnats to our world, and the fact that in other solar systems there are dark planets like our own, may well suggest that the earth is not the only place where life exists. In the present chapter it is proposed to set the problem in the light of modern science; for this "Riddle of the Ages" can not be dismissed till a solution is found, or till the researches of science cease to throw any new light upon it.

Much has been written to show that only two or three of the planets of our system are fit abodes for living things. Mercury is supposed to be too near to the sun for comfort; the moon is believed to be devoid of atmosphere, and therefore incapable of affording oxidation, a necessary condition of life here; the asteroids are thought to be too small to retain atmospheres, and therefore subject to the moon's limitations; and Jupiter and all the rest of the major planets are considered to be still too hot

to admit of the presence of life. Conditions on their satellites are judged by those on the moon, and they are regarded as unfavorable places for inhabitants. Only Venus, Mars, and the earth are considered by most astronomers as possessing all the conditions necessary to life. But all are not agreed as to these things.

Near the middle of the past century the two renowned physicists, William Whewell and David Brewster, the one English and the other Scotch, voiced the two different opinions then prevalent, the latter in his work "More Worlds than One," and the former in his "Plurality of Worlds." Both were influenced in their discussions by the preconceptions of the times, Sir David earnestly supporting them and Whewell making concessions regarding them. In his earlier writings Whewell granted that the greater number of satellites attending those planets farthest removed from the sun indicates a purpose to afford light in sufficient quantities for the needs of living creatures where otherwise it would not be sufficient. But later he wrote: "However destitute planets, moon, and rings may be of inhabitants, they are at least vast scenes of God's presence, and of the activity with which he carries into effect everywhere the laws of nature; and the glory of creation arises from its being, not only the prod-

uct, but the constant field, of God's activity and thought, wisdom, and power." On the other hand, Brewster saw no other object in a planet except to minister to living beings whose purpose in living is to glorify the Creator. According to him, a planet without life on it, or that failed to minister to life, as the moon, would fill no purpose that human reason can conceive. He saw in such a world only "lamps lighting nothing, waters quenching nothing, clouds screening nothing, breezes fanning nothing; and everything around, mountain and valley, hill and dale, earth and ocean, all meaning nothing."

At the close of the third quarter of the century Richard A. Proctor, the English astronomer, in his volume "'Our Place Among Infinites," advanced what he called "A New Theory of Life in Other Worlds." It amounts to the suggestion that the time during which a planet possesses those conditions compatible with life upon it, is but a fleeting moment of its whole duration, a fact which inclined him to Whewell's instead of Brewster's contention, that the support of life is the chief purpose of planets. But, evidently, he was in accord with both, and with most of the scientists of his period, in a tacit assumption which is untenable. The assumption is, that to support life a planet's equipment in general must be sub-

stantially the same as we have on the earth. In Proctor's time some of the remarkable revelations of the spectroscope became known to astronomers, and the discovery of material elements in the sun—and other suns—such as support life on the earth, he regarded as favorable to the conception that life may exist on other worlds.

Now a broader notion prevails. The fact that different species show capacity, some less and others more, to survive in very wide ranges of heat and cold, for instance; the fact that the foodstuffs required by some differ materially from that of others; and the fact that some species produce essences which others are incapable of producing—all goes to indicate that life may not be restricted to the particular conditions with which we are familiar. Besides, the spectroscope has revealed that other planets contain material elements unknown to our planet; and it is possible that there are many elements, wholly unknown to us, which meet the requirements of life quite as well as oxygen, nitrogen, carbon, and hydrogen, for example. Further, it is conceivable that living beings having bodies formed of such material elements might be able to exist under conditions wherein such bodies as are available here would incontinently perish.

Professor Bergson has the following to say with reference to this possibility: "It was not necessary that life should fix its choice upon the carbon of carbonic acid. What was essential for it was to store solar energy; but, instead of asking the sun to separate, for instance, atoms of oxygen and carbon, it might . . . have put forth other chemical elements, which would have had to be associated or dissociated by entirely different physical means. And if the element characteristic of the substances that supply energy to the organism had been other than carbon, the element characteristic of the plastic substances would probably have been other than nitrogen, and the chemistry of living bodies would have been radically different from what it is. The result would have been living forms without any analogy to those we know, whose anatomy would have been different, whose physiology also would have been different. Alone the sensori-motor function would have been preserved, if not in its mechanism, at least in its effects. It is, therefore, probable that life goes on in other planets, in other solar systems also, under forms of which we have no idea, in physical conditions to which it seems to us, from the point of view of our physiology, to be absolutely opposed. . . . That is at least what reasoning by analogy leads to,

and we use analogy the wrong way when we declare life to be impossible wherever the circumstances with which it is confronted are other than those on the earth" (*Ib.* 255, 256).

The no-blooded, the scarce-blooded, the cold-blooded, the warm-blooded, and the hot-blooded animals differ in their proportional use of oxygen; and the plant, brute, and human orders differ in their ability to appropriate the material elements, the plants fixing them directly, the brute taking them in cellular form, and the human employing them instrumentally. Then, the capabilities of each species and order reach down into the domain of those below, and up into the dominions of those above, most suggestively. Everywhere in life phenomena we have these broad hints of what is possible and what is probably accomplished in the infinitely varied conditions throughout the universe.

"As, then, the systems of the universe, and the sciences which treat of them, run into each other and mutually lend and borrow light, illustration, and development, it is a mark of imbecility of mind rather than of strength—of folly rather than of wisdom—for any one to dogmatize with an air of infallibility, or to assume the attitude of perfect intelligence on any subject of human thought, without an intimate knowledge of the whole cosmos. But as such

knowledge is not within the grasp of man, whose horizon is a point within the whole, and whose days are but a moment of time, it is superlatively incongruous for any son of science, or of religion, to affirm that this or that issue is absolutely irrational" (A. Campbell).

However, whether the hypothesis be that of fortuitous beginnings, of instantaneous creation, of creative evolution, or of gradual mutations and survival of the fittest, no conclusion, or set of facts supposed to support it, stands opposed to the conception that there are living beings of various orders throughout the universe. (1) If the Darwinian theory be the true one, a susceptibility and tendency to variation according to conditions of environment, the preservation and perfection of the types best suited to the requirements in the struggle for existence, which slowly overcome hereditary persistence of type, will have obtained in all places throughout the cosmical domain. Accordingly, where longer periods of progress have been experienced, attainments surpassing anything witnessed in terrestrial life may have been already realized. (2) If creative evolution, which assumes that everything "makes itself," be the true theory; if the "exceptional success which life has won at a given moment of its evolution" expresses "the difference of kind, and not only

of degree"; and if "while at the end of the vast spring-board from which life has taken its leap, all others have stepped down, finding the cord stretched too high, man alone having cleared the obstacle"; then some higher kinds of life may with reason be supposed to have leaped to much higher planes of activity, from the vast spring-board, than human life has attained. (3) If instantaneous creation by the Deity be the true doctrine, any conceivable rank or order of life may have existence, from that of the lowest to that of the Creator himself, of course. And finally, (4) if all things began fortuitously, as has been assumed by many philosophers and scientists, as Laplace in his "Nebular Hypothesis," and Loeb in his "Mechanistic Conception of Life," then anything conceivable may reasonably be expected to happen at any time and at any place in the universe. Therefore, we may turn from these theories to the subject in hand without the least fear of contradiction or of contravention from them.

To say that a proposition is not absurd, or that no one is aware of any fact which contradicts it, merely clears the track along which the proofs of it may run. Still, any proposition of which these things may be affirmed will be more easily proved to satisfaction, or will be

more readily shown to be probable, than one against which serious objections may be urged. Some facts and considerations which render it probable that other and higher orders of life than that of humanity exist, will be taken up first, and afterwards such direct proofs as are available will be set forth and carefully considered.

1. Motion is something for which the inert elements of the material world furnish no adequate account. Heat, light, sound, magnetism, repulsion, cohesion, gravitation, all are results of etheric motion; back of this motion is the physio-chemical commotion in the sun, of course; and it may be truly said that the ether, which is kept in motion by the sun, reacts on it with the effect of prolonging its commotion. But this is a temporary condition that may be compared to the vibrations of a tense cord. All such vibrations begin with extraneous impulsion, and tend to cease. It has been heretofore pointed out and illustrated that all sorts of etheric movements tend to cease. The ether is inert. Electricity is inert. Hysteresis in these essences proves this beyond cavil. They, being inert, do not possess the inherent capacity to initiate motion. Neither have any of the material elements. But life has this capacity. Since, then, it is the only essence in the Cosmos known

to us to have the capacity to initiate and to perpetuate motion, the conception that it is the agent of all motion is tenable.

But we all know that there is an infinite variety of motions, terrestrial and cosmical, of which human life is incapable, and which human life certainly does not produce. It is highly probable, then, that all these motions in and of the planets are due to a higher order, or to higher orders, of life in the universe.

Planetary motions are controlled by etheric agitation, or waves of different kinds, and appear to require control at a distance, or telepotence. Human life accomplishes this sort of control, and that where the ether is the sole agent of the accomplishment. There is nothing improbable in the inference that other orders of life may exercise telepotence in a higher degree than is yet possible with mankind. Especially may this be affirmed when this mode of dominance is constantly and swiftly being enhanced in the sphere of human activity, both as regards the greatness of distances over which control is exercised, and as regards the amount of ponderable matter controlled.

Planetary control involves the co-ordination of physical, chemical, thermo-dynamical, electrical, magnetic, luminiferous, and motional effects, and requires that all these effects be

produced through the agency of the ether. A few years ago a miracle exhibiting power equal to all this would have been beyond the dreams of Jules Verne; but human life is fully equal to it in its essential particulars. A gasoline engine is combined with a dynamo as a unit. Electric heat, light, and meter devices are made parts of the system, which is installed in either a boat or an automobile. Now, the boat may be placed on a lake, or the automobile on a race-track, and either may be made to produce all these effects in an orderly manner within the system while the ponderous machine is moving at the rate of a hundred miles per hour along a chosen orbit, the ether alone being the agent of telepotent control by the human operator. It is quite probable that even this amazing accomplishment will yet be exceeded by humanity. It is not improbable that it has already been surpassed by intelligent beings on other planets. Is telepotence impossible with the Creator?

All the mills, all the manufacturing plants, all the railway trains, and all the ocean-going vessels, that are propelled by steam, if taken together, would be an astounding exhibition of power. Back of all this is thermo-dynamics; and back of all thermal sources of energy in the foregoing summary is *zoo-dyamics;* for neither the supposed exhibition, nor any part

of it, would be possible without the agency of mankind. "Zoo-dynamics" is an unfamiliar word, but the idea connoted by it is an old one. In a well-known saying of the apostle Paul, "the power of an enduring life" (*dunamin zoes akataluton*) is the catch-phrase. Let us hope that the time has arrived when the functions of life in physics are to be properly recognized by scientific men.

While treating of reasonable scientific conjecture, the matter of possible supersensible integuments should be considered. We are unable to comprehend how life can act immediately upon matter. We merely apprehend the idea. We are obliged to recognize the fact that it does so. But to meet our views of an individual life, there must be an individual integument for it. A life that does not act through an organism is inconceivable, for the reason that nothing of the kind has ever come within the range of human experience. Besides, all that analogy suggests is, that life invariably exists and operates in some sort of a body.

The facts tending to show the possibility of a supersensible body are numerous and convincing. Glass, one of the hardest of familiar substances, is transparent. Any of the material elements, when in the form of a gas, becomes

invisible. Electricity, which is an indispensable agent in cohesion, eluded discovery for ages, although it pervades every substance with which humanity is acquainted. The ether, whose antitypy or impenetrability is one of the most amazing facts ever discovered by science, is completely beyond the apprehension of our senses. These facts alone afford a reasonable basis for the conjecture that supersensible bodies may exist, and may form living integuments. That they actually do exist as "acoustic clouds," as "air clots," or as "air lenses," has already been shown in a former discussion.

From all these considerations it may be affirmed that every thinkable contingency involved in the hypothesis of super-human life, and that might be required for cosmical control by such life, is broadly hinted and partially realized here upon this planet. The poet David, in one of his loftiest attempts to indicate the might of Jehovah, said: "He maketh the clouds his chariot; he walketh upon the wings of the wind; he maketh the wind his messenger, and a flame of fire his public servant." But this is inadequate to indicate human possibilities in the same field; for man makes the clouds the attendants of his chariot; he flies with wings swifter than the speed of the wind; he makes electricity his messenger, and the ether of space his public

servant! New metaphors are requisite now to convey an idea of superhuman might.

2. In turning to direct proofs of the agency of life in cosmical arrangements and movements, a word is necessary as to the nature of the evidence which ought to be expected, and the showing that ought to be sufficient. When a bacteriologist sets out, with microscope in hand, to discover a germ that is supposed to be the cause of a disease, he does not look for a life. He searches for an organism. He watches material nuclei for motions indicative of the presence of life. The elongation of a cell into a cyclindrical form which is presently seen to be composed of several cells, convinces him that he is witnessing the outworks of a life-transaction. To him the proof is sufficient; and when he announces his discovery to the savants of the age, giving full details of what he has seen, the proof is sufficient for them. It will be possible to present this sort of proof in the present instance, and to give it in a plenitude of evidences which will exceed the requirements of the bacteriological specialists.

Dr. Charles Young, Professor of Astronomy in Princeton College, says in his larger text-book upon his special theme (p. 515): "We see that our planetary system is not a mere accidental aggregation of bodies. Masses of

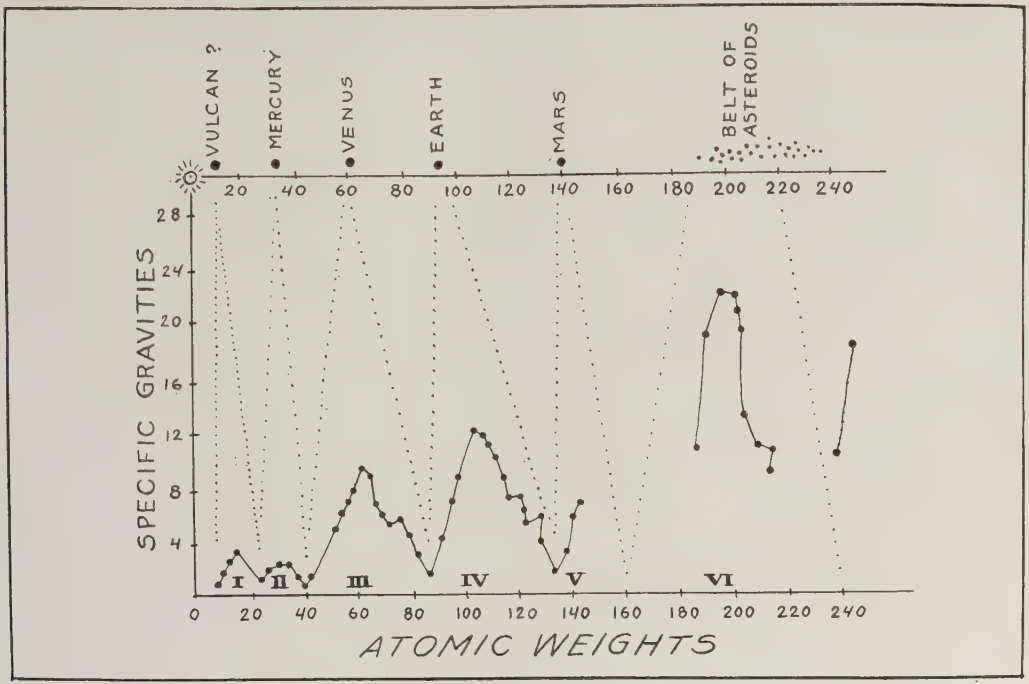
matter coming haphazard towards the sun would move, as comets do, in orbits, always conic sections, to be sure, but of every degree of eccentricity of inclination. There are a multitude of relations actually observed in the planetary system which are wholly independent of gravitation and demand explanation. (1) The orbits are nearly circular. (2) They are all nearly *in one plane* (except the cases of some of the little asteroids). (3) The revolution of all is *in the same direction.* (4) There is a curiously *regular progression of distance* (expressed by Bode's law, which, however, breaks down at Neptune). (5) There is a roughly regular *progression of density,* increasing both ways from Saturn, the least dense of all the planets in the system. As regards the planets themselves, we have (6) the plane of the planets' rotation *nearly coinciding with that of the orbit* (probably excepting Uranus). (7) The *direction* of the rotation is *the same as that of the orbital revolution,* that of the satellites coinciding nearly with that of the planetary rotation. (8) The largest planets rotate most swiftly."

Relations, in a system wherein gravitation is supposed to be the supreme law, that "are wholly independent of gravitation," surely would be something requiring explanation!

Let an instance of these actually observed relations, which appear to be anomalous, be considered in the light of what is known of the matter. That of a progression of distance from the sun will fairly illustrate.

Titius, of Wittenberg, was first to discover this relation; but Johann Bode, the celebrated German astronomer, drew general attention to it in 1772. It is exhibited by writing a line of nine 4's and then placing regularly increasing numbers under the several 4's, beginning with the second. Thus 3, 6, 12, 24, 48, 96, 192, and 384, each increased by 4, will give the resultant series, 4, 7, 10, 16, 28, 52, 100, 196, 388. These numbers divided by 10 are approximately the true distances of the planets from the sun in terms of the radius of the earth's orbit, with the exception mentioned.

This orderly arrangement, according to a regular progression of distances, would be remarkable if there were a corresponding regular increase of sizes and weights of the several bodies, in which case the determinative influence of gravitation would be apparent. With all due apologies to Dr. Young, it must be said that it is not "wholly independent of gravitation." In Chapter V. it is shown to be the result of a systematic differentiation by means of electrical charges, which are in such


VULCAN ?
MERCURY
VENUS
EARTH
MARS
BELT OF ASTEROIDS
20 40 60 80 100 120 140 160 180 200 220 240
SPECIFIC GRAVITIES
28
24
20
16
12
8
4
I II III IV V VI
0 20 40 60 80 100 120 140 160 180 200 220 240
ATOMIC WEIGHTS

proportion to the material mass of each planet as to subject it to determinative actions of gravity. Then, the aloofness of each planet from the sun being a consequence of discreet electrification, the arrangement requires the kind of intelligence and skill displayed by electrical engineers in elaborate and complicate installations. The only difference is that it infinitely surpasses everything in the way of nice and perfect adjustments yet accomplished by any expert human specialists. Any rational man on the earth, finding an orderly system of materials arranged in such relations by such means, would instantly conclude that it must be due to intelligence and not to mere chance. Remember, the man is supposed to be normal. If suffering from some bias, he might think otherwise.

Nothing in the occult sciences is half so wonderful as are the parables of Nature. This remarkable arrangement by electrification of the planets is hinted parabolically in what is known as the Periodic Law. In it we have exhibited many curious relations of the material elements. They differ in capacity to resist heat waves. That is, a greater number of heat units, according to any given standard, will be requisite to raise a given quantity of one element through a single degree than will be required

to raise an equal quantity of another through the same degree of temperature. In this sense, no two of the eighty elements now known have exactly the same capacity to resist etheric agitation of the kind which produces heat. Their differences in this respect are not haphazard, but are so discreet and so regularly progressive as to permit of their arrangement in a series of approximately regularly increasing intervals. The same is found to be true if they are studied with regard to their resistance of gravitational pulses. No two atoms of different elements, when weighed against an atom of hydrogen, are exactly equal in weight. Upon this basis all the eighty different kinds of atoms may be arranged in a progressive series of approximately regular intervals in a scale of atomic weights. This results from the fact that no two atoms ordinarily carry exactly equal primitive electric charges; and since atomic aloofness, which the physicists conceive of as atomic volume, depends upon the size of their respective charges, it follows that no two atoms have the same volume. So, they may be arranged according to their regular differences of volume into a progressive series comparable to those above described. The groupings in the accompanying illustration of the Periodic Law show clearly what is meant.

In these several series a regular progression of aloofness is apparent, and in each series it depends upon discreet electrification, as is apparently the case in the distribution of the planets of the Solar System. There appears to be one law for atoms and for worlds. It may be objected that the "primitive atomic charge" of each elemental atom is a constant; but such an objection would not be urged by the most profound physical chemists. The atomic value varies in connection with different constituents of molecules. An oxygen atom, when attached to one of carbon, contributes 4.4 more to the molecular volume than when attached partially to carbon and partially to hydrogen. Its atomic volume is 12.2 when attached to carbon so as to form the carbonyl group (CO), and 7.8 when it is part of the hydroxyl group (Walker). As would be expected, then, specific gravity varies under etheric heat-waves and with the chemical and physical states of the elements dealt with. The specific gravity of carbon in the form of diamond is 3.3, but in graphite it is only 2.15; and the metals, according to their physical treatment, have different specific gravities. These regularly varying differences of adjustment, which depend upon a naturally variable means of adjustment and which have so indispensable a relation to the order and

efficiency of the whole organism, can not be regarded as accidental. They resemble the processes and motions due to life too closely, and in too many particulars, to be understood in any other way than as phenomena due to life. Besides, their unity and harmony throughout require, both for the results and for a rational explanation of them, perfect co-ordination and co-operation on the part of all the zoo-dynamic agencies concerned.

Periodicity is a prevalent and persistent characteristic of life phenomena. The individuals of all species of terrestrial life pass through regular periods of growth, maturity, and decay. Few things are better known than the time-limits for adult or sexual maturity of the individuals of the different species. The time for the maturation of eggs, the time for their development after fertilization into larva, pupa, embryonic, and other like periods of growth, and the average age-limit for the adults of all sorts of living things, are too well known to require elaboration before introducing the great truth of this characteristic of life phenomena into this study. The specifications that might be made would fill a volume. The periodicity of diseases is always due to either the time required for the development of the germs which cause them, or to cycles which are normal

to the body of the patient. Neither chemistry nor physics can furnish any explanation of all this—or any of it. Neither can astronomy give any approximately satisfactory explanation of the still more amazing facts of the faultless periodicity characteristic of the movements of the planetary bodies in the universe. From data furnished by ancient astronomers it is admitted that the earth has not varied one minute in its annual circuits about the sun during the past two thousand years. There is practically no limit to the number of similar statements that might be made about every planetary body in the Solar System. Nor is this peculiar to the Solar System, as all intelligent persons are aware. Far-away Algol and his companion, for instance, whirl about each other in their rhythmic cosmic dance in perfect time; and, so far as the most improved telescopes enable us to look into the remote regions of space, perfect periodicity marks the movements of all the cosmical phenomena.

If it be objected that periodicity is not exclusively a life phenomenon, seeing that electrical, chemical, and physical processes are characterized by time-limits, the answer is ready. All that we know of the genesis of motion goes to prove that, somewhere, life is the prime cause of it; and although periodicity was not set down

as one of the characteristics of vital phenomena, to go to the roots of the matter, it might have been. Until philosophy, with the aid of the sciences, makes it clear that motion of any kind can have an absolutely original cause which is not life, we may confidently hold on to the idea of periodicity, cycles of moving bodies in the cosmos, and time, as being due to the agency of life, because all motion is due to life.

The conception that all atomic and molecular structures are products of life, and that all chemical and physical motions and changes affecting their relations have their final explanation in the agency of life, should not be rejected simply because the *modus operandi* of it can not be fully comprehended by humanity. If the bacteria of culture solutions should become schools of philosophy, we should find it instructive to study the conclusions they would necessarily reach. Dr. Schizophyta, president emeritus of one of these schools, would be justified in saying, from his point of view, that there are no forces nor agencies concerned with the solution within which his tribe resides, except the physio-chemical forces of the salts and fluids thereof. With a fine irony he might scout the notion that a being of inconceivably greater mind and capacities had weighed the salts in a balance and apportioned the fluids by measure.

Still, he would be in the wrong—blamelessly in the wrong.

Cycles, and periods, and time express relations: relations to motion and sphericity. Now we may ask two profound questions which relate to things that seem to lie very far apart in the cosmical arena, but that have one and the same solution: (1) Why are cells, the smallest material units in living matter, spheroidal rather than crystalline in form? and (2) why do planets move in orbits instead of straight lines? Biologists will not hesitate to answer the first by attributing the spheroidal form of cells to the agency of life, saying that this is an invariable characteristic of its operations. This being all that the present state of knowledge enables one to say that is exactly pertinent, we may pass on to the other question. But we would not be justified in answering this by saying simply, "It is due to the agency of life." As Dr. Young says, it demands explanation.

The expositor must begin somewhere back of Laplace's nebulous cosmos in vortex motion. For back of this there must have been integrative motion to bring together the particles composing the nebula. Suppose a particle to exist in the midst of a great void. In this case the whole cosmical space must be that void. To have it complete, the ether must not occupy it.

In the ether the particle would meet resistance. Philosophers say that the whole etheric region, which is co-extensive with space, is a vast magnetic field. The void must contain *nothing*. If motion be now imparted to the unit of matter, it will continue eternally to move directly away from that which gave the impetus, unless it is interfered with; and its motion will be eternally in a straight line. To impart to it true orbital motion, requires the direction of its motion to be changed at every conceivable point of its progress, and to be so changed as to bring it to a point in the void having a definite relation to the point from which it started. At every point of divergence from a straight line inertia must be overcome. If we go back of all secondary causes and speak of prime causes only, we know of nothing in the universe except life that is capable of overcoming this inertia. Therefore, when we get to the root of it, so far as our experience and knowledge enable us to judge, the orbital motions of the planets are due to the agency of life. So are all cosmical periods. So is time.

But the astute physicist will say the absolute void is confessedly imaginary. The planets move in their orbits through the ether of space, and are subject to the influence of all the magnetic lines of force which are ever active in

all the illimitable regions of the Cosmos. But one answer can be given. All this being true, an "original impetus" would not be sufficient to insure even tangential motion indefinitely. It has previously been made evident that so-called "magnetic lines of force" arise from the ether. For want of better terms we speak of heat billows, light waves, and gravitational pulses; but all these effects are due to the agency of the ether; and back of its billows, and waves, and pulses, and vortices, and quiverings, and reactions, is a high order of life, which is dominant in all motion in the Cosmos.

A further objection might occur to some minds, that the instances of superior dominance of human life appealed to to show the reasonableness of the conception of zoo-dynamic control in the Cosmos, are instances of instrumental or mediate control; whereas the co-ordination and direction of all material things upon which the universal order depends, supposing this to be a vital dominance, necessitates the immediate dominance of the material elements and essences. Or, granting that etheric and electric influences are always back of physical and chemical processes, it requires at least immediate control of these essences, or of that one of them on which the actions of the other depends. The indicated condition of adequate illustration is

frankly accepted. Control *by* the ether is mediate and instrumental; but control *of* the ether in starting primitive motion necessitates immediate control. But it is evident that human life, and every other order of life, is equal to the immediate dominance demanded by the condition.

Let it be admitted that the so-called "direct fixing" of chemical elements by plants is, when properly understood, accomplished mediately through the ether and electricity as the agents of integration. Still, this requires the immediate control of that one of these essences by whose agency the other acts. For very good reasons this is supposed to be the ether. Again, when one lifts his hand, the required contraction of his muscles is a physical process accomplished mediately through these essences; but it requires the immediate dominance of the instrument of the physical process. At bottom vital dominance in the physical world depends upon the immediate control of the most attenuated not-living essences. This being necessarily true, the condition demanded by the objection is fully met.

To sum up, energy, impetus, motion, dominance, continuity, order, periodicity, and time, interdependent as they are, and maintained as they are in the Cosmos, can not be scientifically

accounted for except as the results of the rationally directed power of an "enduring Life." Whether this Life be called Deity, God, Jehovah, Allah, Shin, Kami, or any other name a nation or a people may employ for its designation, the evidences of its existence are so manifest as to appeal to the common sense of all mankind; and when this universal judgment is scientifically tested, the only rational line of thinking justified by science and philosophy brings to it the strongest possible support.

Zophar, Job's friend, whom nobody supposes to have been inspired or infallible, expected a broad negative answer when he asked the patriarch, "The hidden depth of God canst thou discover, or unto the furtherest limit of the Almighty canst thou attain?" With all due respect for the inquiry, whatever reply he may have expected, no patriarch, or seer, or apostle, or authority, whether religious or secular, can set bounds to the possible discoveries and attainments of mankind; and any investigation we may elect to pursue scientifically, is now regarded as legitimate. More than this, many of the deep things of the adorable Supreme Life have already been discovered, and surprising attainments are leading us on through what appears to us to be the illimitable domain of the Almighty.

XIV.

Persistent Ancient Ideas of Life.

The old and still persistent conception of the Cosmos and of Life which have come down to us from the ancient Hebrews, were not acquired by them through scientific investigations, of course. All thoughtful persons, whatever may be their opinions as to a revelation from God, will be interested in a brief comparison of some of these ancient conceptions with those which scientific researches have enabled modern philosophers to form.

Avoiding all disputed points as to authorship and dates of composition, the Septuagint Version of the Old Testament was in the Alexandrian Library at least one hundred and thirty years before the beginning of the Christian era. It contained the Pentateuch and the Book of Job, which are conceded to be the oldest books in the Bible. These were regarded as venerable writings at the time the translation was made by "the seventy" scholars for Ptolemy's collection, from which circumstance it took its name. This dates the conceptions disclosed so far back of the discoveries of modern science as to acquit

the writers of any suspicion of having borrowed their ideas from the philosophers of more recent times. That they are ancient conceptions, then, there can be no dispute nor doubt.

The Pentateuch opens with the statement that "in the origination, God created the heavens and the earth: and the earth was without form, and was void." The whole context shows that the author intended to convey the idea of the primordial beginning, or the beginning of everything in the universe that ever began. For he not only uses a different term for the makings detailed in the account of the "six days" of the first week, with two exceptional instances, but he implies a thoughtful and discriminate use of the two terms by saying that on the seventh day God rested from the work which he had "created and made." Also he was careful to say, both as to the brutes and as to mankind, that they were made of the dust of the earth, or of matter already in existence. To interpret fairly, "dust" here stands for the smallest known particles of the material world—the "ultimate particles" then known, just as, until recently, "atoms" were the ultimate particles with our modern scientists. In brief, the Pentateuch begins with a twofold idea of origins; the idea of the absolute beginning of the material universe, and the idea of the second-

ary origin of things made of the pre-existing elements. This corresponds to our modern discrimination between "the Azoic age" of planets and of the universe, and "the Protozoic age" and subsequent ages and periods. The further particulars of the account show this to be a fair construction of the first of Genesis.

"The earth was without form." This can mean nothing else except that it had no permanent shape. Strictly speaking, this is still true of it; for both the ocean and the solid crust of the globe yield to gravitational pressures which result in appreciable changes of its shape continually. But during the Azoic age of the planet this was one of the conditions which made it an unsuitable place for the abode of living things. It was "void." That is, it was without tenantry. In modern scientific parlance, *it was azoic*. How long this condition continued, the account does not even intimate. Nor do the scientists know. Here the perfect agreement takes the form of absolute silence.

Like most of our astronomical statements, those in Genesis about the Cosmos are phenomenal, in the sense that they describe conditions as they appear to be from the earth as the point of view. When an astronomer says that a star in the belt of Orion is on the celestial equator, or that a star in a certain constellation will be

on the celestial meridian at a given hour, he means "as seen from the earth," though he rarely adds this limiting clause. So the idea set forth in Genesis, that the appearance of light on our planet succeeded the archaic, azoic, mist-enveloped condition, and was the first act of the Creator preparatory to the introduction of living things upon it, is in very exact agreement with the prevalent belief of philosophers that the earth was once in the condition in which they find the planet Jupiter at this time; that is, so completely enveloped in dense vapors as to exclude the light of the sun and of other stars from its surface. Twice this primitive condition, as differing from the present condition and as due to enveloping vapors, is clearly intimated in the Mosaic account. As seen from the earth, the light must have appeared before the sun was visible. At any rate, the writer of Genesis had the notion that it did, and in expressing this notion he anticipates modern scientists; for they think this must have been so.

On pages 47 and 48 attention is incidentally directed to another of these remarkable anticipations. The Mosaic account of the suspension of the enormous quantities of water in the heavens, which at any time is about equal to all the flowing water on the earth, is that "God made an expanse to separate the water above,

from the water beneath the expanse; and it was so." As may be seen on the pages referred to, modern science has discovered this fact independently, and has pointed out that the upper atmosphere is "in a state of electrical strain" which gives to particles of vapor a potential different from that of the earth. It is difficult to say whether "expanse" or "state of strain" is the more accurate expression for the condition described; but it is not difficult to perceive that the difference is merely one of the choice of terms, the idea being very exactly the same in both cases.

The limits of inter-breeding afford the only basis of classification in botany and zoology. Any other *principii divisionis* are more or less arbitrary, and the classes formed under others are overlapping. For instance, *omne vivum ex ovo* being now admitted by all naturalists to be true at least of all animals, the distinction between *ovipara* and *vivipara* is arbitrary. The classes *omnivorous, carnivorous, herbivorous, graminivorous,* and *frugivorous* are overlapping. Men, dogs, and hogs are capable of being any of these. They may all be *pachyderms* also; for it has not yet been scientifically determined *how* thick a skin must be, to be thick! In Genesis we read: "Let the earth bring forth grass, the herb yielding seed, and the fruit-tree yield-

ing fruit after its kind, whose seed is in itself, upon the earth: and it was so" (Gen. 1:11). "And God made the beast of the earth after its kind, and cattle after their kind, and everything that creepeth upon the earth after its kind" (Gen. 1:25). Here is the conception that there is a limit to the inter-breeding which can not be successfully broken down, the perception of a law of the species which can not be set at naught. But on pages 258 and 259 it has been shown that the leading investigator in America in the department of biology dealing with the physio-chemical laws of progeny, refuses to believe that any true mutants have yet been produced by inter-breeding; and in giving the reason for his disbelief, he reduces these statements of Genesis (unwittingly) to the terms of modern science. He says "a given type of nucleins will continue to synthesize other nucleins of its own kind. This determines the continuity of a species, since each species has, probably, its own specific nuclein or nuclear material." This conception, then, one of the latest of modern science, is in Genesis first, and first in Genesis, by over two thousand years at least.

The conception that life comes from pre-existing life, and that it is essentially different from material things, is plainly set forth in this

ancient book. That "the Lord God formed man . . . and breathed into his nostrils the spirit of life, and man became a living soul," is a statement expressing clearly the idea that the life of man emanated from the life of his Creator. It also implies that life is a something essentially differing from the material components of the physical organism (Gen. 2: 7). In Job this distinction between body and life is brought out more specifically. We read: "If a man die, can he live? All the days of my warfare would I wait, until my relief should come. Thou shouldst call and I would answer thee" (Job 14: 13-15). Again: "But as for me I know that my Redeemer liveth, and at last he shall stand up upon the earth: and after my skin, even this body, is destroyed, then without my flesh shall I see God" (Job 19: 25, 26). In the chapter on life it has been shown that the greatest of modern philosophers conceive of life as a distinct essence, though they do not profess to know what it is, or whence it came to this planet. But the ancient books have anticipated them in the notions that it is entitative, that it differs essentially from material essences, and that it came to earth from pre-existing life.

We have seen that the characteristic differentia of the human species is in the superior

mode of human dominance. We read in Genesis: "God said, Let us make man in our image, after our likeness; and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over every creeping thing that creepeth upon the earth" (Gen. 1:26). Here is the conception that man was made to dominate all other mundane life. Also that the characteristics fitting him for his dominance are comparable to those of his Creator rather than to those of any other living thing; and it is so.

These old notions are invariably implied or expressed incidentally in the Scriptures; but it is quite sufficient for the comparison being made, to show that the writers of these ancient books had the conceptions which have been brought forward for comparison with modern views. They held them as having been revealed to their ancestors by Jehovah. Whether this claim is tenable or not, their belief in them as revealed truths led to a conscientious preservation of them without modification through the centuries. It thus happens that the New Testament writers incidentally show us how tenaciously they were held by the Hebrews throughout their generations; and in a most singular way, the like of which will hardly be found in the history of any other people, these conceptions persisted in

spite of all the modifying circumstances of their national existence.

It would be easy to select and quote passages from the New Testament which show that every particular notion above mentioned as being very ancient, was still held by the Hebrews in the time of Christ and his Apostles. Paul says: "Through faith we understand that the worlds were framed by the word of God, so that the things which are seen were not made of things that do appear." Again he says: "God made the world and all things therein. . . . He giveth to all life. . . . For in him we live, and move, and have our being; . . . we are the offspring of God." Such endorsements as these abound in these later writings.

These citations are quite sufficient to show that those ancient writings preserved these conceptions from the earliest Hebrew period to New Testament times; but the most remarkable thing about all this is yet to be stated. In spite of the contact of the Israelites with Canaanites, Syrians, Egyptians, Chaldeans, Greeks, and Romans, several specific notions which are of the essence of these conceptions are expressed in the so-called New Testament Greek by a discriminate use of three different words that correspond to Old Testament primitive roots which make the same discriminations in the

ancient Hebrew. Especially may it be said "in spite of Greek influence"; for, although some of the writers were learned Hellenists, such as the apostles Paul and Luke, who knew well the Greek usage, they also used the Greek terms as intentionally adapted to express the several persistent old notions.

1. When the very essence of life is connoted, whether conceived of as in the body or out of it, *zoe* is always employed; as, *e. g.,* "In him was *life,* and the *life* was the light of men."—"Because I *live,* ye shall *live* also."—"Eternal *life.*"—"Be thou faithful unto death, and I will give thee the crown of *life.*" For the higher ethical notions also *zoe* is used; as, *e. g.,* "Our *life* is hid within God."—"Jesus Christ, who hath abolished death, and hath brought *life* and immortality to light."—"The Prince of *life.*" In every case the entitative life is meant.

2. When the terminable aspect of life in the body is connoted, involving the idea that the relation between the body and the *zoe* is temporary, the word *psukee* is used; as, *e. g.,* "Herod sought the young child's *life.*"—"I will lay down my *life* for thy sake."—"He gave his *life* a ransom for us." In this use death is implied, of course, because it is always conceived of as the severing of the relationship between the *zoe* and the material integument. But no

New Testament usage ever implies that the *zoe* can cease to be, though the *psukee* is represented as perishing; as, *e. g.,* "He poured out his *soul* unto death."

3. When the duration of life, the manner of life, or the means of living, are connoted, *bios* is invariably employed. We may say that in the New Testament life phenomena are signified by this word; as, *e. g.,* "The cares and riches and pleasures of this *life*"—"the pride of *life*"—"the affairs of this *life*"—"a quiet and peaceable *life.*" In all these instances *biography* is implied.

This restricted usage for *zoe* and *bios* is widely different from what we find in the classic Greek. The scholarly Dr. R. C. Trench, after saying that the two chapters with which the *Gorgias* of Plato concludes are sufficient to bring out fully the distinction between these words, says: "But this being the case, *bios* and not *zoe,* being thus shown to be the ethical word in classical antiquity, a thoughtful reader of the Scripture might very well inquire with something of perplexity, how it is to be explained that there [in the New Testament] all is reversed."

The reason has been already intimated. The Hellenists, having chosen these several words to translate the several words in which their

own language held their cherished notions of life, persisted in this restricted and discriminate use of them with a tenacity and unanimity unequaled by anything else in literature; for, without opportunity for collusion, learned and unlearned Hellenists observed perfectly all the restricted uses of these several root-words and their numerous derivatives. In the Old Testament, for instance, *nephesh* occurs seven hundred times, and the corresponding word, *psukee,* is used one hundred and five times in the New Testament; both are translated into Latin by *vita,* and into English by *life;* yet not once in the Bible is the word *immortality,* or *immortal,* or *deathless,* or *never-dying,* found in connection with either, as qualifying it. Many Christians would be as surprised upon learning that "the immortality of the soul" is nowhere taught in the Scriptures, as they would be pleased to hear that the essential life (*zoe*) is always represented as imperishable by the Bible authors.

Another remarkable fact is, that not once do these authors apply *bios,* or *zoe,* or *psukee,* or any one of their Hebrew equivalents, to any member of the vegetable kingdom. Ammonius, an Alexandrian philosopher of the fifth century, asserts that *bios* is never, except incorrectly, applied to plants or animals, but only to mankind. However this may be, in classic usage

bios and not *zoe* is the higher term, as Trench points out. But in our language the word *biology,* unsupported by either usage, stands for the broad idea of life phenomena in both the animal and the vegetable kingdoms, and it will doubtless hold its place.

To sum up, the persistent conceptions are, that life (*zoe*) is *the builder;* the soul (*psukee*) is *possession* of the house; *bios* is its occupancy while it lasts. Possession may be given up. Occupancy may cease. The builder is indestructible. "But God is the builder of all things." "For by him we live, and move, and exist." "God is the producer of all creation; because by him was created everything in the heavens and upon the earth—seen and unseen— . . . and he himself preceded all, and by him all things consist."

There is a fine passage in one of Emerson's essays in which the magnanimity and entireness of a great friendship are compared to the impartial and ceaseless shining of the sun, whether his rays fall upon responsive objects or not. This is more than anticipated by Jesus Christ when he says of his Father: "He causes his sun to shine on both the bad and the good, and sends rain for both the just and unjust."

This is finer and more profound in that it points to the activities of the adorable and almighty Life back of the sun's beneficent, impartial, and ceaseless shining.

Our study of the physical world, whether the investigation be of its vastest or of its minutest processes, leads inevitably to the contemplation of that ALMIGHTY LIFE.

THE END.

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